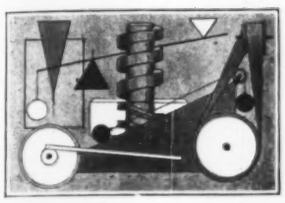
MACHINE DESIGN

as it affects

ENGINEERING–PRODUCTION–SALES

Volume 4 | October, 1932 | Number 10



Forthcoming ISSUES

THERE is an old saw which claims that "liquids are practically incompressible," yet recent experiments have proved that considerable compression can take place. In some cases this is an advantage; in others a detriment.

Energy expended in compression of fluids and factors of the phenomenon which influence design will be presented in an early issue of MACHINE DESIGN. *The article should prove of particular interest to diesel engineers and to designers considering the application of hydraulics to machinery.*

L. E. Jermy

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HAROLD B. VEITH
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J. F. AHRENS ..... *Eastern Manager*
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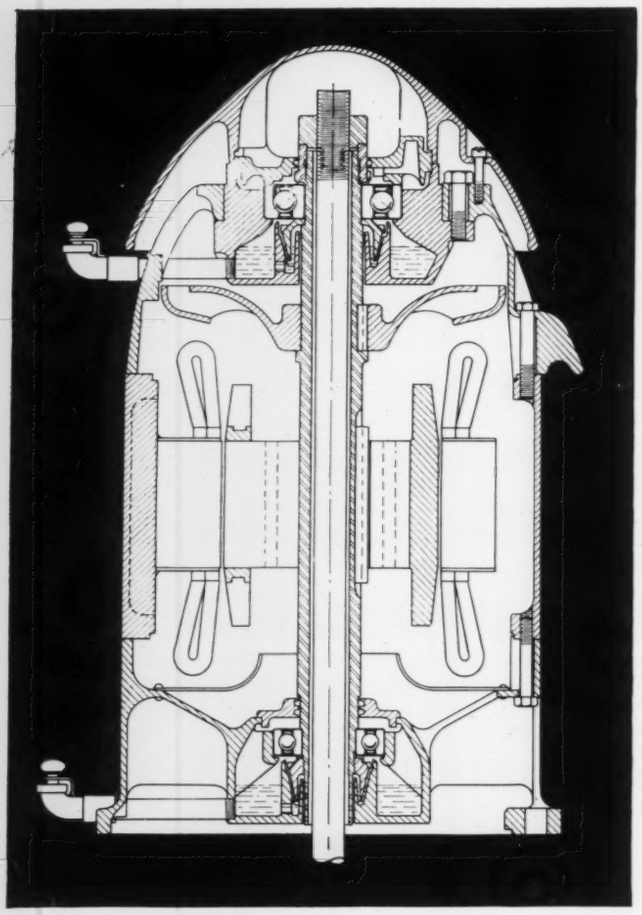
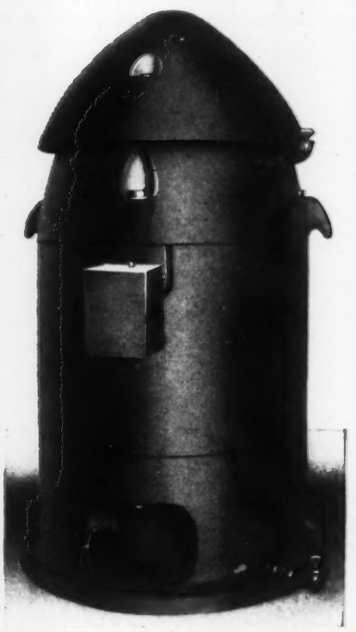


Good bearings

. . . *properly applied*



MOST of the work-loads in a vertical deep-well pump fall on the thrust bearing located in the upper position. These loads involve the weight of parts suspended in the well and the weight of a rising water column. Moderately high speeds, ever changing weather conditions, and inattention from owners make this a most difficult bearing assignment. But Westinghouse users are doubly sure of dependable operation, because of good bearings, properly applied. The large New Departure angular contact bearing in the upper position of the pump shown here is capable of tremendous thrust loads. The ingenious slinger keeps it constantly lubricated when in use. Tough, enduring steel and easy rolling motion prevent wear. Hairline accuracy guarantees proper electrical functioning. And maintenance costs are negligible because "nothing rolls like a ball." The New Departure Manufacturing Company, Bristol, Connecticut.

1915

NEW DEPARTURE BALL BEARINGS

Itemized Index, October, 1932

Key: Edit, Editorial Pages; Adv, Advertising Pages; R, Right hand column; L, Left hand column

Compiled for the assistance of engineers confronted with specific design problems

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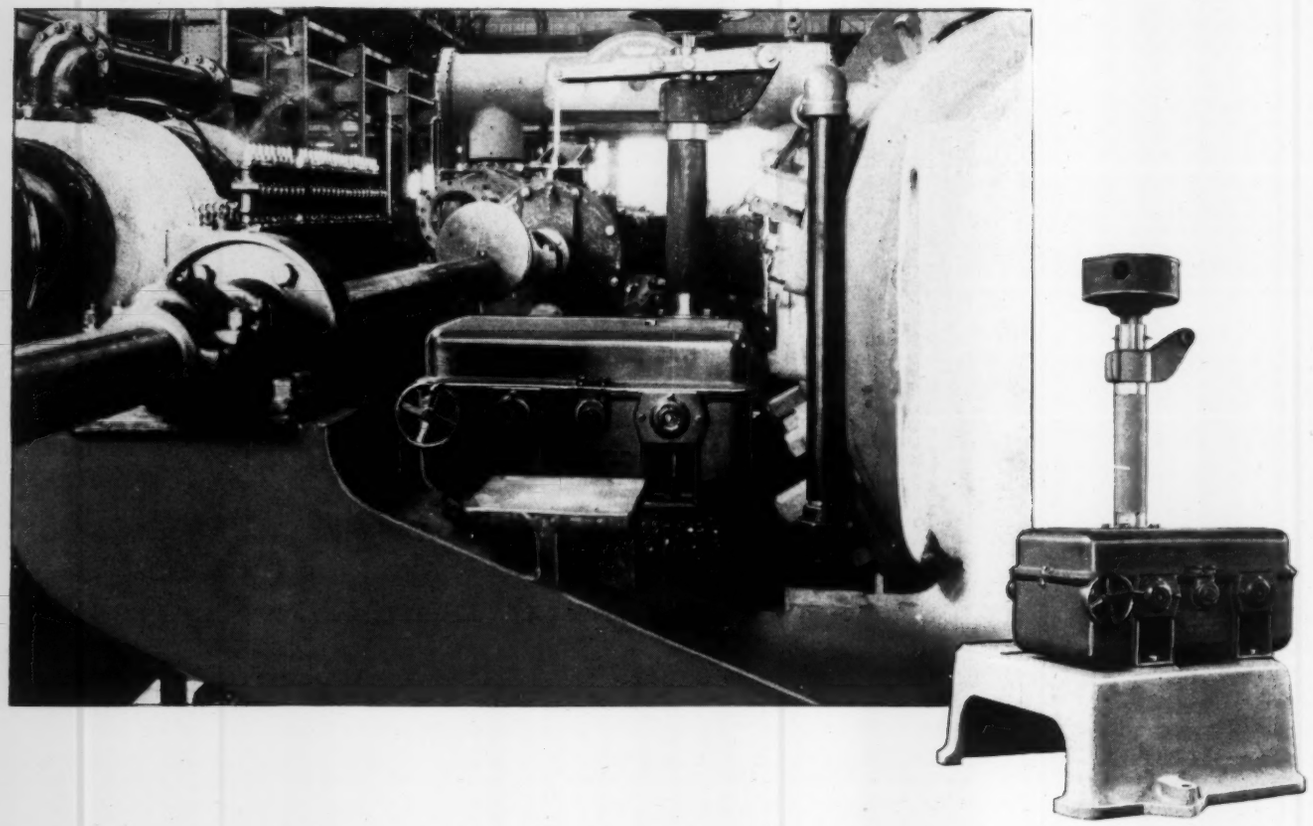
THE pace of progress never was swifter than it is today. Almost daily something new emanates from research in mechanical, electrical, metallurgical or chemical engineering, which means new materials, new methods or new parts for the use of engineers responsible for design.

One of the primary functions of Machine Design is to watch these developments and to advise its readers promptly of every new discovery which will in any way affect design.

THE LEWELLEN TRANSMISSION



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October, 1932 Vol. 4—No. 10

Unit Assemblies Facilitate Production

By Max L. Jeffrey

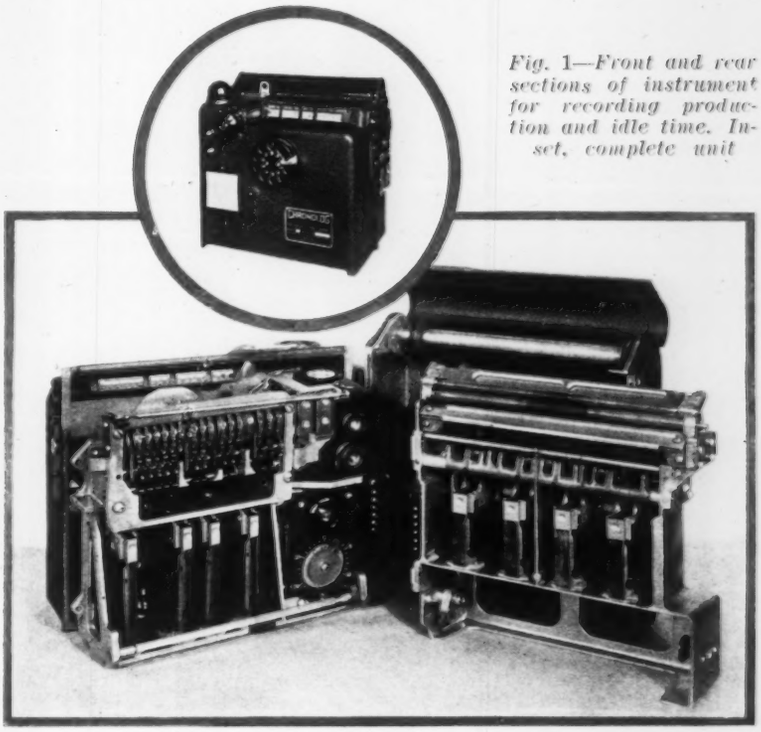


Fig. 1—Front and rear sections of instrument for recording production and idle time. Inset, complete unit

INTERCHANGEABLE parts manufacture was established about 1800, Eli Whitney being the guiding genius of this system in its initial stages. With the introduction of Whitney's miller and later machine tools the system was refined, and there probably has been no other engineering achievement from that day to this which has contributed so much to the advancement of manufacturing methods.

Only in comparatively recent years, however, have engineers given serious consideration to extending the system to include completely interchangeable unit assemblies, planning these units as components of the finished design. Where such procedure can be adopted the advantages immediately are apparent. Not only is the process of assembly greatly simplified in respect both to bench work and final assembly, but servicing also becomes a more simple problem. Added to these results is the fact that changes in the design of the asemblies, if found desirable, can be carried out more readily and the new units installed at minimum expense.

An excellent example of a machine built up largely from unit asemblies is found in the new Chronolog of the National Acme Co. depicted in its complete form in the inset in Fig.1. The machine, or instrument, is intended for installation on any type of production machine for recording idle time, productive time and a count of the quantity of parts produced. The operator is kept informed constantly of the foregoing, while for the use of the plant superintendent at the end of the day or whenever necessary a detailed printed record is made. Indicated on this record are the visits to the machine of the supervisor, inspector, repair man, stock man, etc., thus showing graphically the influences which may be at work in the creation of idle machine time during the day's run.

Of primary importance in the design of the instrument are the registering and printing solenoids, shown respectively in the assemblies at the left and right of Fig. 1, and the clock unit. Solenoids of conventional design were tried out in early

models but proved unsatisfactory due to the amount of space occupied. Normally, electromagnets of the type required are not provided with the extended portions of the laminated pole pieces, as at *a*, Fig. 2. In consequence an exceedingly large coil winding is necessary to create the magnetic force necessary to overcome the air gap in the open position. In the new design, by bringing the plunger head *b* within the confines of the extended pole pieces, the variable air gap at the head of the plunger is eliminated and replaced by a constant air gap of extremely small proportions between the plunger head and the pole pieces. A more powerful magnetic action thus is obtained, while the size of the solenoids is held down to satisfactory dimensions.

Solenoids Operate Registering Wheels

Actuation of the counting solenoids, shown at the extreme left of Fig. 1, is effected by switches that are mounted on the production machine to operate by means of contacts each time a part is produced. The second, third and fourth solenoids from the left revolve the registering wheels for recording production time, idle time and clock time. Each of these solenoids is actuated by contacting devices of the time unit. Other solenoids, shown in the assembly at the right of the same illustration, operate printing pads that press the paper on which the record is kept against the registering wheels. These latter solenoids are energized every five minutes or at other predetermined intervals during the regular run by the synchronous motor clock mechanism shown in the unit assembly at the lower right of Fig. 3. The solenoids also operate whenever the control switch of the instrument is turned to the "on" or "off" position, regardless of the time interval.

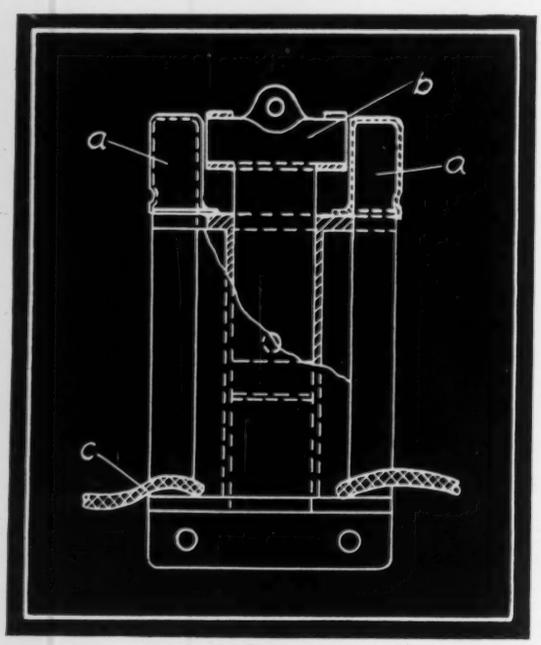


Fig. 2—Pole pieces of solenoid are extended to provide constant air gap of minimum dimensions

Each of the symbols on the face of the dial in the assembly at upper center of Fig. 3 represents a specific reason for machine stoppage, with the exception of letter P, representing production. Other symbols designate "down for stock," "cleaning," "repair," etc. Dialing of any of these causes the printing pad solenoids to operate, thus recording the complete status of the job at that time as well as the reason for stoppage of the machine, and directing the circuit through the solenoid operating the registering wheels for accumulation of idle time instead of through those accumulating production time. A ratchet mechanism is provided which locks the dial in the selected position, the return to the "P" or "on" position being effected by the pressing of a manually operated push button or by actuation of an automatic release lever by the counting solenoid when production again starts.

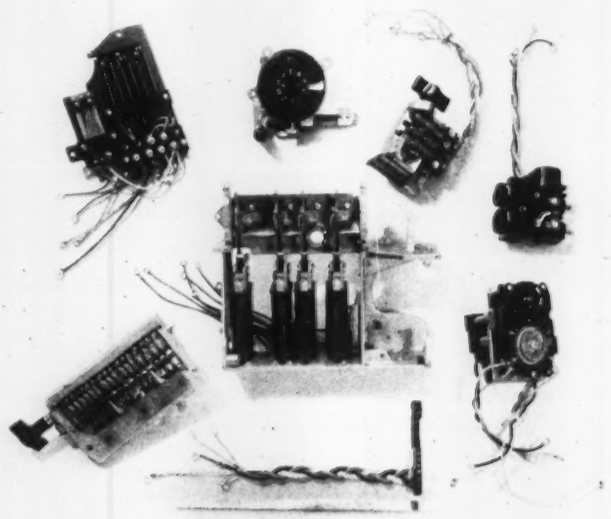


Fig. 3—Complete set of front frame unit assemblies. Frame is shown in center with solenoids in position

One of the most interesting mechanical movements in the machine is involved in the rotation of the registering wheels referred to in the foregoing. In order to obtain the desired columnar effect of the printed numbers and at the same time utilize a minimum amount of space, all of the registering wheels are mounted on a single shaft. When the shaft is pressed endwise by actuation of the set-back knob to turn the printing rings, interlocking pawls inside the registering wheels are released and ratchet pawls are permitted to engage in notches in the main shaft. Thus all the wheels can be set back to zero, with the exception of those for indicating the clock time and the reason for idle time.

The clock time wheels rotate on a sleeve that fits over the main shaft, the minute wheel being mounted on one end of the sleeve and a gear

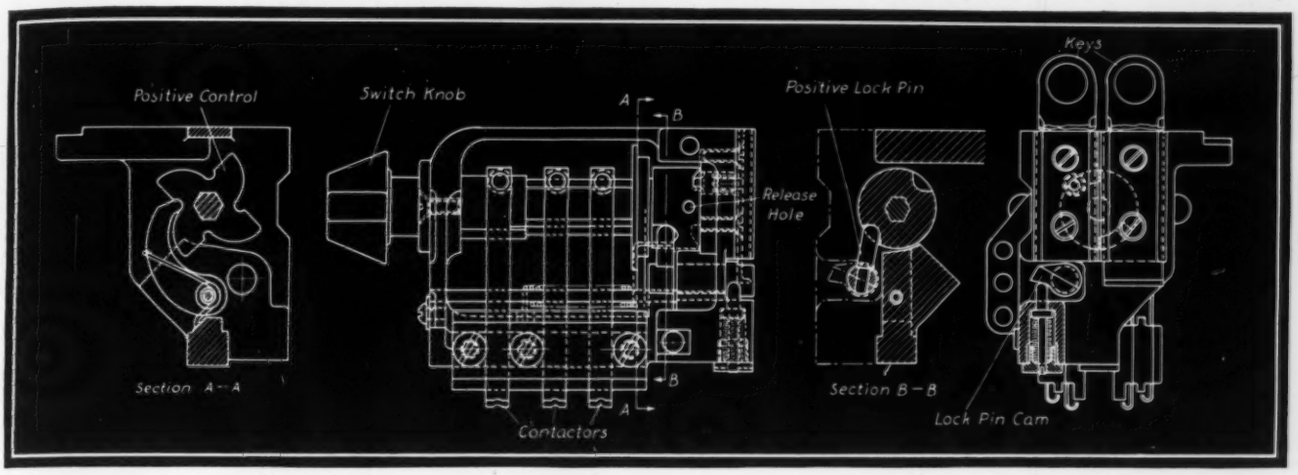


Fig. 4—Control switch unit assembly. Switch cannot be turned until the left-hand key of the two shown in view at right is inserted. This is the operator's key; the second key may be that of the inspector, foreman or other individual

on the other. This gear meshes with a gear on the shaft beneath and the clock time registering wheels therefore may be set by rotation of this lower shaft by a clock key. Each set of registering wheels has a ratchet wheel attached to it which actuates the others in the set. This ratchet wheel is operated by its respective solenoid plunger, the energizing of the solenoid pulling down the plunger by a hook and thus indexing the wheel to the next position. The gearing is such that one complete turn of the first registering wheel causes the next wheel to index one position. Indexing of more than one number each time the solenoid is energized is made impossible by the shape of the hook and back stop provided.

Embossed Number Plate Affixed to Key

The control switch assembly unit, shown in Fig. 4 and at the upper right of Fig 3, is one of the devices that, although it appears simple in the final form, required as much consideration in design as any other section of the instrument. Since the use of keys was desirable for the operation of the locking mechanism of this unit, and the recording of the identification of the individual inserting a key also was necessary, it was decided to put each individual workman's number on his key in such a manner that this number, on insertion of the key, would come into line with the numbers on the registering wheels and be printed with them on the record. The operator's key is inserted in the left-hand slot of the two shown in Fig. 4 and contacts with the lock pin cam indicated. Operation of this cam in turn releases the lock pin and makes possible the turning of the switch knob. Another lock pin is provided which holds the key in place when the control switch is "on" and prevents removal of the key until the switch is turned to the "off" position. The other key slot is intended for insertion of the key of the foreman, inspector or other individual visiting the machine, whose identification and time of visit thus can be recorded.

Positive contact of the control switch is provided for in the design of the star wheel and spring lever mechanism, Fig. 4. A release hole, as shown in the main view, is provided in the barrel at the "off" position, the purpose of this being to receive the end of the main shaft carrying the registering wheels when pressed in to reset the wheels. When the barrel is at the "on" position the hole does not line up with the end of the registering wheel shaft and for this reason the wheels cannot be reset except when the instrument is turned off.

The first set of contacts near the switch knob, Fig. 4, carry all the circuits to the various mechanisms except the time unit, these contacts being closed when the knob is turned to the "on" position. The other four contacts are made during the process of turning the switch to either position thus operating the printing and paper indexing mechanisms to record the standing of the registering wheels at the starting and finishing of a job or period. The paper feed rolls are indexed by the solenoids that actuate the printing pads, immediately prior to printing.

Utilize Die Castings and Stampings

Though early models of the Chronolog were made largely from sheet metal and sand castings, quantity production permits the use of aluminum die castings for both sides of the case, the frames and also a number of smaller parts. Practically all other parts are made up of stampings or plastic materials. Due to the accuracy necessary, machined steel rings with engraved characters are used for the registering wheels.

Hard baked, wrinkle enamel has been adopted as the best finish for the exterior of the unit. In addition to being economical, experience has proved that minor scratches or finger prints do not mar the appearance of this finish.

SCANNING THE FIELD FOR IDEAS

A Monthly Digest of New Machinery, Materials, Parts and Processes, with Special Attention to Significant Design Features and Trends

X-Ray Images in Three Dimensions

X-RAY testing is providing the engineer with an important tool by which the soundness of machine members, physically and from a design standpoint, may be studied. A basic discussion of this method of testing was presented in the September issue of MACHINE DESIGN, and as indicated in that article rapid strides are being made in X-ray work. In this connection a new development that makes possible three-dimensional images is particularly significant.

At California Institute of Technology Dr. J. W. DuMond and Dr. A. Hoyt have invented and constructed X-ray stereofluoroscopes which will give stereoscopic images, in three-dimensional, plastic relief. There is no other stereoscopic method by which this perception of and localization in depth can be effected satisfactorily. If it is useful for the purpose in hand, the three-dimensional image can be put in front of the fluorescent screen and formed as a "life-sized-ghost" into which calipers can be inserted so that direct measurements can be made with a precision of less than a millimeter. In addition to this the stereofluoroscope is useful anywhere the ordinary X-ray fluoroscope can be used.

The machine consists of two X-ray sources, separated by a distance equal to the interpupilary distance, which flash X-rays alternately 60 times a second. These flashing X-rays cast alternate shadows on a fluorescent screen which is viewed through a synchronous optical shutter or image selector near the eyes. By means of the synchronous shutter each eye sees the series of shadows cast on the screen by its own X-ray source and none of the shadows cast by the other X-ray source. These two different sets of shadows seen separately, one set by each eye, are fused together into a three-dimensional, stereoscopic image.

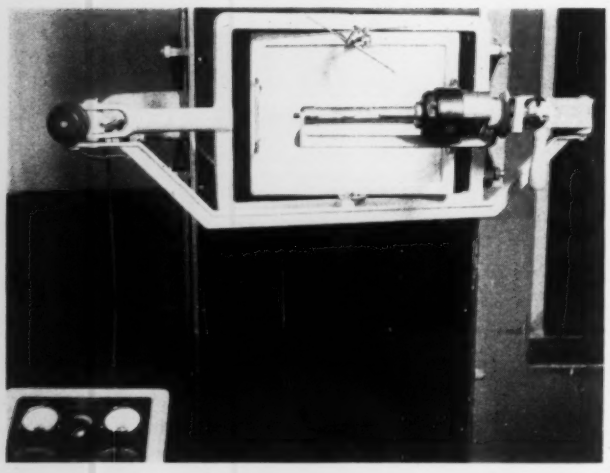


Fig. 1—X-ray stereofluoroscope constructed at California Institute of Technology and installed at Henry Phipps Institute, Philadelphia

Has Application to Castings

The limit on the thickness of castings and welds that can be inspected by means of the X-ray stereofluoroscope is set by a characteristic property of the material—its X-ray absorbing power. It is principally this property of the material which sets the limit on the thickness although there is another minor factor involving the characteristics of the human eye in relation to its ability to detect the faint light coming from the fluorescent screen. However, a simple calculation shows that if the X-ray tube is run at 150 kilovolts peak, aluminum castings not thicker than 1½ inches could be tested for "blow holes" and flaws which would give fairly sharp contrast.

In the instance of iron the limiting testing thickness would be ¼-inch because iron is a material of much higher atomic number. Physicians make use of an X-ray fluoroscope for studying human beings but their requirements are easier to fulfill in that a much lower voltage is needed and any attempt to use one of their standard machines for casting work would result in only about one-quarter the penetration which is obtainable at the present time. It is apparent that it is possible to build a stereofluoroscope that will be useful in testing small aluminum and iron castings, but it probably is unwise to attempt to adapt existing fluoroscope designs, as has been done for medical work. The thing to

do is to build one from the ground up allowing for the increased voltage, the specialized job in hand, and more exacting measures for the protection of the operator.

A direct comparison between the study of castings by means of stereophotographs and a stereofluoroscope can now be made. Stereophotographs take longer to make, give more detail, make a permanent record of the casting tested, give one "still" three-dimensional picture of the casting and can be obtained of somewhat thicker castings if the exposure time of the film is sufficiently increased. On the other hand the stereofluoroscope would give much more rapid examination of somewhat thinner castings, furnish no permanent record of castings tested, show a little less detail but give a moving picture in three dimensions of each casting tested. The particular type of castings to be examined and their use will determine to a large extent the type of equipment that will do the testing job most effectively.

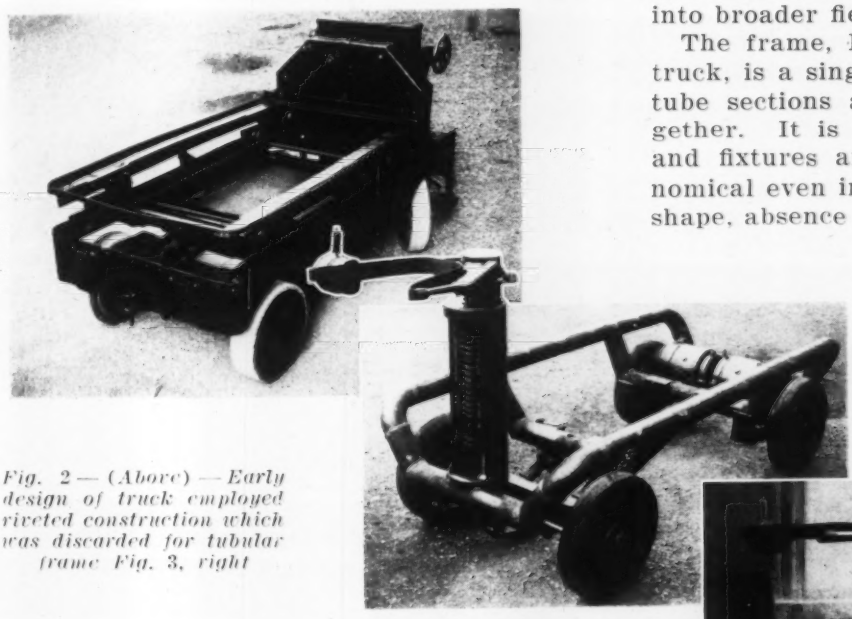


Fig. 2 — (Above) — Early design of truck employed riveted construction which was discarded for tubular frame Fig. 3, right

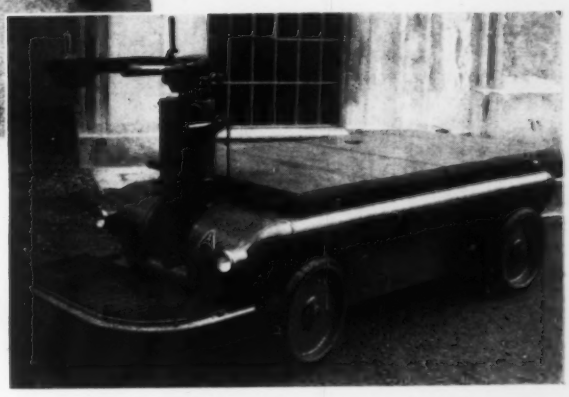


Fig. 4 — (Below) — Redesigned truck embodying arc welding tubular members. Note improved appearance over old unit

Redesign Improves Appearance

TUBULAR construction long has been employed in bicycle and aircraft design with comparative ease. Because the tubular members were thin-walled, fabrication was simply a process of connecting them by means of sleeves, tube turns or T-fittings and brazing them together. Different problems, however, present themselves in using larger tubes for heavier classes of work. These were overcome in a redesigned heavy electric truck, the changeover of which from a riveted to a welded tubular unit is described by Georg Hafergut, Weiz bei Graz, Austria, in a prize-winning paper entered in the recent Lincoln arc welding competition.

Redesign Employs Arc Welding

Before introducing arc welding and tubular construction into the manufacture of the truck, steel plates, rolled shapes and various castings and pressed parts were employed in the riveted construction, Fig. 2. The redesigned unit, Fig 4, is typical of the extent to which the designer can effect marked savings by studying other fabricating methods. The idea involved in this and similar instances should carry its influence into broader fields.

The frame, Fig. 3, the principal part of the truck, is a single unit consisting of 14 straight tube sections and four tube turns welded together. It is fabricated without special tools and fixtures and therefore production is economical even in small quantities. The rounded shape, absence of rivet heads, etc., also enhance its appearance. In addition the car wiring is placed inside the tubes with water and dustproof outlets. All parts such as spring bosses, pedestal supports, supports for the storage battery, coupling hooks, frame of platform and brackets of the platform are arc welded to the tubular frame.

Vacuum Finds Another Use

DRIVING of fan motors for automobile heaters is one of the most recent applications of the vacuum created in the intake manifold to which designers have turned for a profitable source of power. The innovation augments the line of apparatus in which vacuum is employed, including windshield wipers, automotive timing,

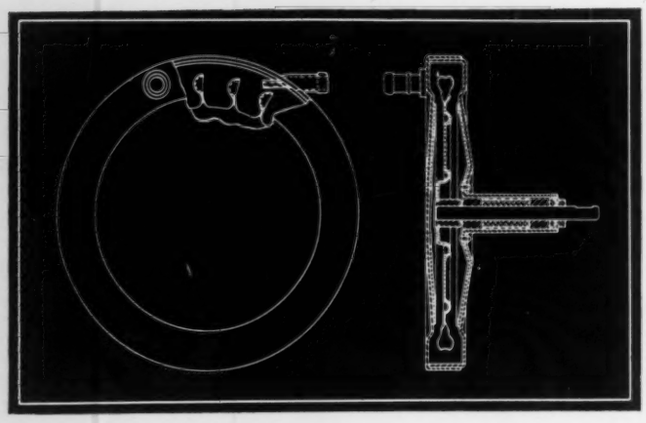


Fig. 5—Stream of air drawn by vacuum created in manifold drives blades of vacuum motor

clutches and vacuum brakes. Almost simultaneously comes the development of a vacuum control unit which performs the functions of an automatic clutch control and vacuum brake booster manufactured for the Ford V-8.

Many theories on the air wheel were considered by Delta Corp., Detroit, before the unit, Fig. 5, was built. Carburetor engineers were called into consultation to determine the safe amount of permanent air bleed that could be admitted into the intake manifold without disturbing carburetion. After this point was established the formula for a well known water wheel was utilized and an experimental model built.

In operation a constant stream of air is drawn through a jet which has a 3/32-inch opening, this air stream being drawn by vacuum against a series of paddles to rotate the rotor to which they are fastened. The Delta vacuum motor on the average car, it is claimed, will turn a 6-inch fan at electric motor speed with the vacuum produced at 35 to 45 miles per hour.

It is true, of course, that on acceleration there is a sharp drop in the vacuum, but both the air motor's rotor and the fan will have a definite momentum which keeps the fan rotating until acceleration ceases. The fan of the motor is designed to circulate air through a hot water heating coil. One of the advantages of this type of unit is that it does not drain the automobile storage battery.

Tire Employs No Air Pressure

PROVIDING a snow-shoe effect in loose or soft soil or sand, a new tire has been developed which deflects readily under load and lends unusual tractive qualities to vehicle wheels on which it is employed. "Zero Pressure" is the name by which the B. F. Goodrich Rubber Co., Akron, O., identifies this tire, because no air pressure is employed.

The tire consists of a rubber arch built on a slotted steel base for application to solid tire wheels. Piers of the arch are of sufficient size and rigidity to provide ample carrying capacity. Resiliency which causes bouncing, slippage and wheel spin is absent in the new product.

Speed Increased by Multiple Engines

MULTIPLE engines recently drove Gar Wood's MISS AMERICA X at a speed of 124.915 miles per hour to establish a new record on water. The craft was equipped with four engines, two more than used in MISS AMERICA IX which was capable of 111.712 miles per hour. This accomplishment is indicative of the capabilities of multiple engined units.

Another noteworthy mechanical feature of the craft which won the Harmsworth trophy is the supercharger mechanism attached to the engines as shown in Fig. 6. It will be noted there are two compressors per motor, each unit feeding one bank of six cylinders. The compressors rotate at twice engine speed and deliver 8 pounds of intake manifold pressure.

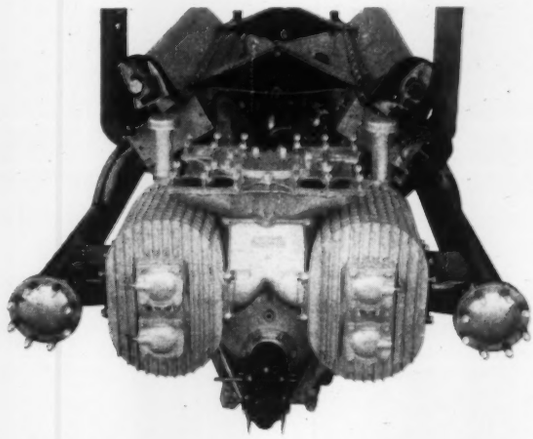


Fig. 6—Superchargers used on one of the engines on Gar Wood's record breaking boat

Each Packard engine employed has 2540 cubic inch displacement and delivers without superchargers 1000 horsepower at 2340 revolutions per minute. With the superchargers they deliver at the same speed 1490 horsepower, and at 2600 revolutions per minute 1650 horsepower. Compression ratio of the engine to the supercharger is 7½ to 1. The drive of the compressor is obtained from the crankshaft through a rubber insert coupling which absorbs torsional vibration. This coupling drives a heavy gear which acts as a semi-flywheel and has the same effect as a harmonic balancer.

Vertically Cut Grooves Save Space

THOUGH normally a wave form is desirable for increasing the distance between two points, a particular instance in which such waves are disadvantageous occurs in the manufacture of sound-producing records. Vertical cutting of

grooves therefore has been adopted in a method recently developed by Bell Telephone Laboratories Inc., New York. A recent issue of the *Record,* published by that organization, contains a comprehensive discussion covering this method of recording on wax. With this procedure the stylus is moved up and down, thus leaving a groove the depth of which varies according to the sound.

Vertical cutting gives a series of hills and valleys along the grooves and often is referred to as "hill and dale." It is illustrated in Fig. 7. In reproducing from this type of record the needle is held to the bottom of the groove by an unbalanced portion of the weight of the reproducer head. Inherent reduction in distortion that could be obtained with vertically cut records was disclosed by analysis and preliminary studies.

Fig. 7—Comparison between horizontal wave and vertical "hill and dale" cutting shows space conserved by latter on sound-producing record

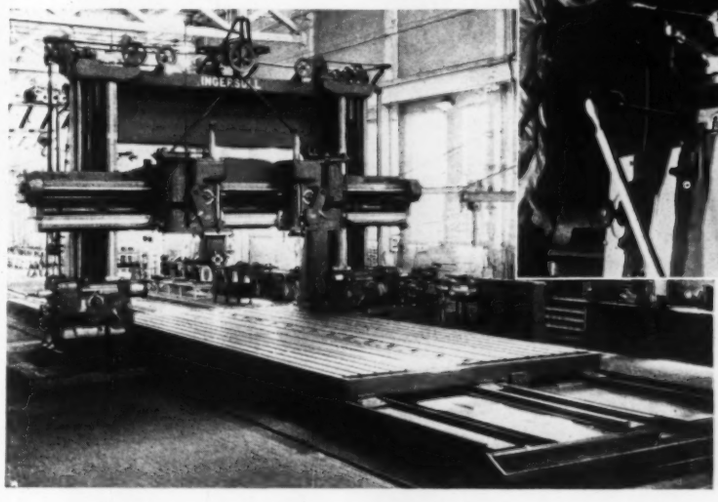
The vertical cutting process makes more easily possible an increase in the loudness range because a greater depth of cut does not necessitate a corresponding increase in spacing of the cutting groove as in the case of the side cut record. Thus a standard 12-inch record may be produced that will play from 15 to 20 minutes on one side, with better sound reproduction.

A new form of phonograph employing these records and electrical reproduction seems an attractive possibility since 15 or 20-minute records of music almost indistinguishable from the original would be invaluable, says H. C. Harrison, who has been engaged in research along this line at the Laboratories. One of the fields of immediate usefulness is that of the production of high quality records for broadcasting purposes.

Unit Embodies Centralized Control

SIGNIFICANT as an outstanding accomplishment in design is the milling machine built recently by Ingersoll Milling Machine Co., Rockford, Ill. The unit is the largest constructed in this country, having capacity for a casting 15 feet wide, 11 feet high and 40 feet long. The bed is 80 feet long.

In addition to its size the feature which characterizes this unit is the centralization of controls at one station as shown in Fig. 8. One panel controls the four drive motors with a push button and rheostat control for each, while the other panel includes the feed motor control and all gear change levers. The feed motor is independent and provides feed and rapid traverse in either direction to the table, rail, heads and quills. Unusual ease of control is demonstrated by the fact that the operator is able to set any adjustment to .001-inch with the jog button control.



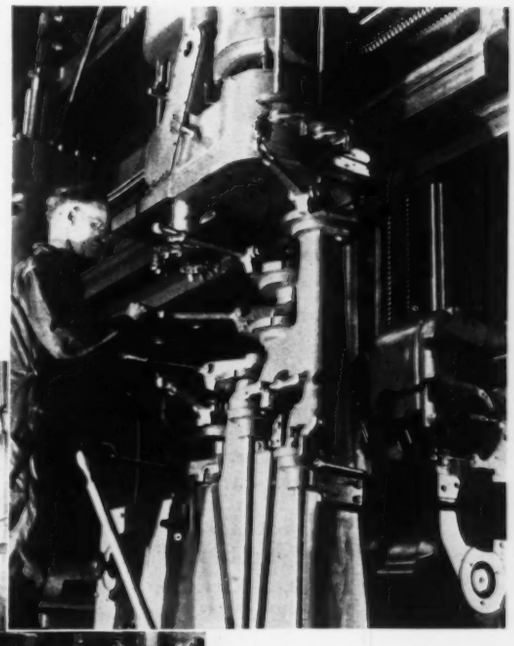


Fig. 8 — Centralization of controls characterizes this milling machine which is the largest in this country. Location of controls has been given consideration in the design as indicated above

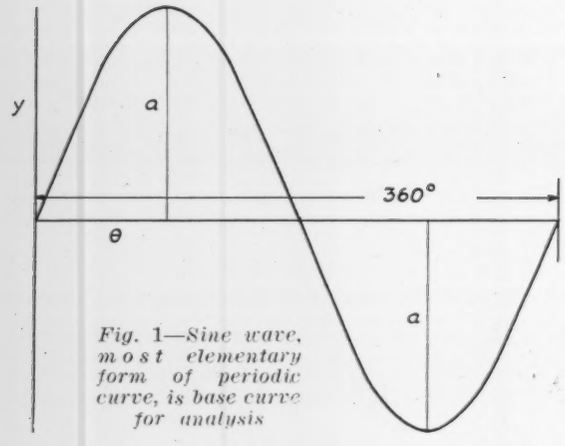


Fig. 1—Sine wave, most elementary form of periodic curve, is base curve for analysis

Simplifying Steps in H

By W. R. Spiller

REFINEMENTS of design frequently are the determining factors in the success of a given piece of machinery. Such items as the elimination of noise and vibration are being given constantly greater attention by the expert designer and he is forced to acquire knowledge which he formerly did not need, for it often is the case that these problems require the application of more involved theories than he is accustomed to use. More than often he may tackle this new knowledge in the numerous text books and articles on the subject and come up against an impasse of higher mathematics which may discourage him to the point of withdrawal.

A practical instance of this is found under the problem of vibration. It is unquestionably a field which requires deep study before intelligent attacks can be made on its solution, and numerous excellent articles have appeared on the subject which well repay study. There is one step in the solution of vibration problems, however, which appears to have been neglected almost universally by these articles, apparently because it is a mathematical tool which is assumed to be in the possession of the reader. This step is Harmonic Analysis.

Must Analyze Actuating Forces

A complete study of a vibration problem nearly always involves the determination and analysis of the actuating forces, and sidestepping this part of the problem results in an imperfect grasp of it. According to an expert on diesel marine drives,[1] "the analysis of these vibration problems is absolutely dependent upon the Fourier harmonic analysis. In fact, it scarcely would be possible to deal with these problems at all without the use of Fourier's powerful and beautiful theorem, instruction in which is too seldom given in engineering schools to other than electrical students."

This theorem, discovered by Fourier more than a hundred years ago, in its wider applications no doubt is of the brain stretching type of higher mathematics, but a useful understanding of its essence may be had readily by one whose knowledge extends no further than trigonometry. This article therefore visualizes the meaning of a harmonic analysis and describes a simple method of making one. Acquaintance with the subject should lead the wide awake designer to many practical applications of the development.

Vibration Builds Up Quickly

Without going deeply into the subject of vibration it might be well to review the elementary physics involved in most problems met with in machine design. Any member of a machine which has elasticity and mass is capable of a vibratory motion in one or more natural frequencies. When a periodic force is applied to this member having the same frequency or *containing a component of the same frequency* the phenomenon of resonance sets in, and the resulting vibration builds up to a point limited only by the factor of damping. This divides the problem into three main parts: Natural frequencies; actuating forces; and damping. This article deals only with the methods for resolving the actuating force into its separate components.

Harmonic analysis is essentially the breaking down of a complicated phenomenon into its component parts. The phenomenon must be capable of representation as a curve repeating itself periodically. A mechanical example of such a phenomenon is the motion of a follower actuated by a rotating cam. This motion may be anything which design dictates, yet it also may be conceived as *the summation of a number of sine waves,* the sine wave, Fig. 1, being the most elementary type of periodic wave form. This is the basic principle of Fourier's theorem and may appear to be a mathematical trick. It will

[1]Frank M. Lewis in the discussion of "The Elimination of Torsional Vibration," by George J. Dashefsky, *Pennsylvania State College Bulletin,* No. 12.

Harmonic Analysis

be seen nevertheless that the separation into sine waves of a periodic curve has a real physical significance. If, for example, a number of tuning forks of different frequencies forming a musical chord are set into vibration together and the resulting sound is reproduced graphically as a pressure wave on a time base, it is possible by harmonic analysis to resolve this wave into its separate sine waves or harmonics and thus determine the frequencies of the different tuning forks. In the case of the cam motion referred to above, if the cam follower is restrained by a spring, the actual presence of the harmonics may be detected by observing the vibration of the spring.

Frequencies Always Whole Multiples

A further important condition of Fourier's theorem is that the frequencies of the separate sine waves composing the irregular periodic curve always appear as whole number multiples of its frequency. Thus it may be stated that if the frequency of the periodic curve is one, then the frequencies of the component sine waves are one, two, three, four, etc., to infinity, and never a fractional part of the fundamental period. Experience with harmonic analysis will show quickly that the latter condition as cited would be impossible.

Definitions of the various terms used in the derivation are:

Sine Wave: A wave form which may be plotted as a curve of the equation $y = a \sin \theta$

Period: The interval, generally in time units, for one complete vibration.

Frequency: The reciprocal of period or the number of vibrations per unit of time

Amplitude: One half the total height of a wave

Harmonic: One of the elementary sine waves composing a periodic curve

Fundamental: The sine wave having the same frequency as the composite wave—the first harmonic

Order: The order number of a harmonic is the number of cycles completed during the period of the primary curve

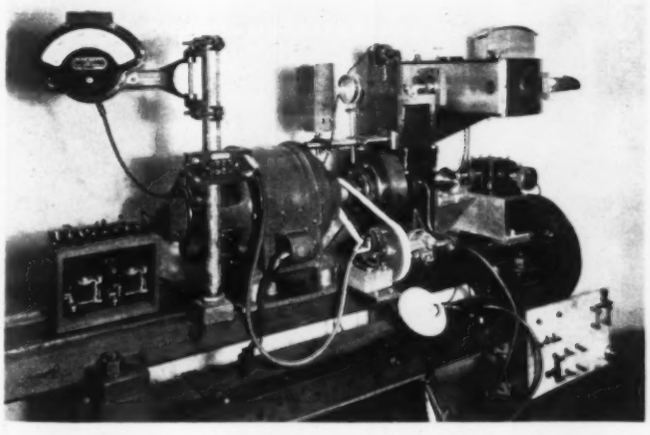


Fig. 2—Machine especially designed to study the phenomenon of spring vibrations

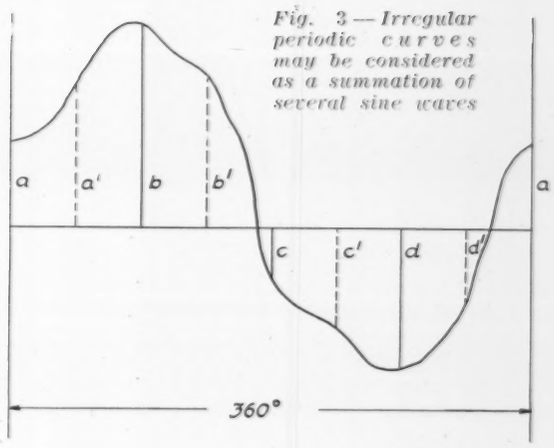


Fig. 3—Irregular periodic curves may be considered as a summation of several sine waves

It may be thought that the resolution of a periodic wave may be carried out only on a smooth wave form, but this is not the case. Harmonic analysis may be carried out equally well on rectangular or sharp pointed waves. The wave may be discontinuous, dropping vertically from one value to another, as is encountered frequently in acceleration curves, provided it does not pass through infinity. Another limitation is that the curve must not loop back on itself, that is, it always must proceed forward. These limitations are not of practical significance so that it may be considered that any periodic curve in engineering practice is subject to harmonic analysis.

Since any given periodic curve may be resolved into a series of sine waves, it follows that it is possible to write the wave in the form of a mathematical equation. This is a most useful device if it is desired to perform mathematical operations such as addition, integration or differentiation on the curve. Primarily, however, the purpose of writing the Fourier series in equation form is to present a mental picture of the

elements composing the composite wave. A common method of expressing a Fourier series is;

$$y = a_0 + c_1 \sin(\theta + \phi_1) + c_2 \sin(2\theta + \phi_2) + c_3 \sin(3\theta + \phi_3) + \ldots\ldots\ldots\ldots + c_n \sin(n\theta + \phi_n) \ldots\ldots\ldots\ldots (1)$$

where

y = any ordinate of the periodic curve at the corresponding θ
a_0 = the average height of the area under the curve
c_n = the amplitude of the nth harmonic
θ = the abscissas of the curve generally expressed in degrees, with 360° representing the period of the curve
ϕ_n = the phase angle of the nth harmonic with the primary curve

Examination of equation (1) reveals the meaning of this series. Except for the first term, which is a constant, all the terms on the right hand side of the equation contain sines, and are therefore the separate harmonics. The term containing sin 2θ represents the second harmonic, that containing sin 3θ is the third harmonic, etc. Each harmonic is identified by a constant factor c_n which is its maximum amplitude and by a phase angle ϕ_n which determines the starting point in relation with the primary curve. The constant term a_0 is the y distance from the centerline or average height of the curve to the base line. Thus a harmonic analysis consists in determining the maximum amplitude of the individual harmonics, their phase angles and the average height of the primary or composite curves.

Convenient Form Presented

A more convenient form of Fourier's series which eliminates the phase angle and therefore simplifies the analysis is as follows:

$$y = a_0 + a_1 \cos\theta + a_2 \cos 2\theta + a_3 \cos 3\theta + \ldots\ldots a_n \cos n\theta + \ldots. + b_1 \sin\theta + b_2 \sin 2\theta + b_3 \sin 3\theta + \ldots\ldots b_n \sin n\theta \ldots\ldots (2)$$

In this equation each harmonic contains two terms, a cosine term multiplied by a constant a_n and a sine term multiplied by a constant b_n

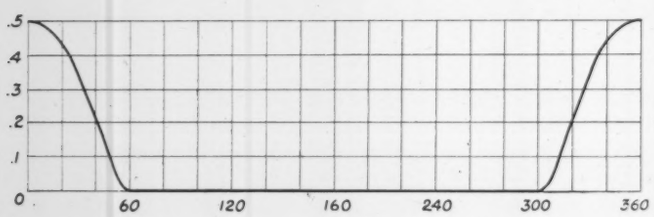


Fig. 4—Curve for poppet valve motion is plotted so as to start at the mid-point of symmetry

The maximum ordinate a of a harmonic may be obtained from the relationship

$$c_n = \sqrt{a_n^2 + b_n^2} \ldots\ldots\ldots\ldots (3)$$

and the phase angle ϕ_n from the relationship

$$\tan \phi_n = \frac{a_n}{b_n} \ldots\ldots\ldots\ldots (4)$$

Knowing the a_n and b_n values for any harmonic thus determines the harmonic and the complete analysis consists in separating these values from the primary curve. It is interesting to observe that this equation may express practically any periodic curve whatsoever simply by changing the values of the coefficients of the harmonics.

The process of harmonic analysis may be done readily by calculus *provided the periodic curve has a known equation.* This condition is extremely rare and resort nearly always must be made to one of three methods: Mechanical analysis; graphical processes; or arthimetical processes.

Available Instruments are Complicated

The first two methods may be dismissed for the average engineer, as available instruments are complicated and expensive, while graphical methods probably are no more rapid than arithmetical tabulations and are somewhat questionable as to accuracy.

Various schemes of tabulation have been proposed for making a harmonic analysis and the fact that they all involve considerable labor need not be disguised. Prominent among these arithmetical methods are those proposed by Steinmetz, Runge and Thompson. It is probable that the last two named are used most generally as they are the most rapid. For a harmonic analysis where only the lower harmonics are desired, the system of groupings proposed by Runge is quite useful and descriptions of this scheme may be obtained from the references in the attached bibliography of Dr. F. W. Grover and P. Cormac.

The Thompson method has several distinct advantages. In the first place it permits the separation of any individual harmonic desired without making a complete analysis. Furthermore its accuracy, outside of personal errors, is determined by the length to which the analysis is carried. A further advantage of this method is that experience in using it gives a visualization of the process not otherwise obtained.

Determining the Mean Value

Concerning this method, Prof. S. P. Thompson says; "the fact that if a series of $2n$ ordinates is measured at intervals apart of π/n where n is the numeric representing the order of the harmonic, and if their values, taken alternately positively and negatively, are averaged over a whole period, the mean so obtained is either simply the amplitude of that harmonic or else is the sum of the amplitudes, and of certain higher harmonics, viz. those the ordinal numeric of which is an odd multiple of n. For cosine components the series of $2n$ ordinates must begin, (or end) at the beginning (or end) of the period. For sine components the series must begin at π/n from the beginning of the period."

The basis of this process rests on the fact that

if a periodic curve is divided into a number of equal intervals and the ordinates of these points are measured from a base line drawn at the mean height of the curve, then the sum of these ordinates divided by the number of intervals is the ordinate of the harmonic of the same order number plus the ordinates of all harmonics

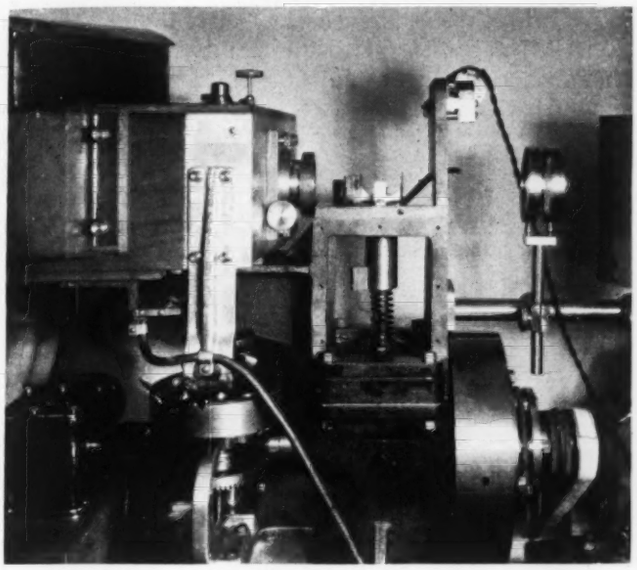


Fig. 5—Photographic records of actual spring vibrations have been taken from tests on this machine

which are multiples of this order number. For example, if a periodic curve as shown in Fig. 3 is divided into four parts and the four corresponding ordinates are added together algebraically $(a + b - c - d)$ and divided by four, the result is the ordinate of the fourth harmonic plus the ordinates of the eighth, the twelfth, the sixteenth, etc., harmonics. By Thompson's method twice as many ordinates are measured and instead of adding them all together they are alternately added and subtracted algebraically. The result then is divided by twice the number of intervals, giving the value of the ordinate of the harmonic with all the even multiples eliminated.

Curve Is Divided Evenly

Applying this to the foregoing example, the curve is divided into eight parts and the ordinates are added and subtracted alternately and divided by eight. In Fig. 3 this becomes $(a - a^1 + b - b^1 - c + c^1 - d + d^1) \div 8$. The result thus obtained is the ordinate of the fourth harmonic plus the ordinates of the twelfth, the twentieth, etc. A particular advantage of this process lies in the fact that it makes no difference from what base line the ordinates are measured, so that it is not necessary to find the mean height of the curve as a preliminary step to the computations.

To determine the maximum ordinate of any given harmonic it is necessary to traverse the curve twice by this process, once for the cosine coefficient a_n and once for the sine coefficient b_n The traverse starting at the beginning of the curve gives a_n, while the traverse for b_n must start at one quarter the wave length of the harmonic away. This may be expressed as starting at $\theta = 360/4n$ degrees from the beginning of the curve. Having obtained a_n and b_n, the maximum ordinate of the harmonic c_n is found from equation (3). Greater accuracy is obtained by determining the values of the odd multiple harmonics and subtracting them.

Complete Process Described

The complete process for making an analysis of ten harmonics may be carried out in the following manner. The curve is first plotted on cross-section paper as accurately as possible so that it covers about eight inches for the total height of the wave and eighteen inches for the complete period of 360 degrees. It is usual to use degrees for abscissas. Ordinates then are read off and tabulated as follows, the subscripts referring to the angles at which the ordinates are read.

$$a_{10} = (y_0 - y_{18} + y_{36} - y_{54} + y_{72} - y_{90} + y_{108} - y_{126} + y_{144} - y_{162} + y_{180} - y_{198} + y_{216} - y_{234} + y_{252} - y_{270} + y_{288} - y_{306} + y_{324} - y_{342}) \div 20$$

$$b_{10} = (y_9 - y_{27} + y_{45} - y_{63} + y_{81} - y_{99} + y_{117} - y_{135} + y_{153} - y_{171} + y_{189} - y_{207} + y_{225} - y_{243} + y_{261} - y_{279} + y_{297} - y_{315} + y_{333} - y_{351}) \div 20$$

$$a_9 = (y_0 - y_{20} + y_{40} - y_{60} + y_{80} - y_{100} + y_{120} - y_{140} + y_{160} - y_{180} + y_{200} - y_{220} + y_{240} - y_{260} + y_{280} - y_{300} + y_{320} - y_{340}) \div 18$$

$$b_9 = (y_{10} - y_{30} + y_{50} - y_{70} + y_{90} - y_{110} + y_{130} - y_{150} + y_{170} - y_{190} + y_{210} - y_{230} + y_{250} - y_{270} + y_{290} - y_{310} + y_{330} - y_{350}) \div 18$$

$$a_8 = (y_0 - y_{22.5} + y_{45} - y_{67.5} + y_{90} - y_{112.5} + y_{135} - y_{157.5} + y_{180} - y_{202.5} + y_{225} - y_{247.5} + y_{270} - y_{292.5} + y_{315} - y_{337.5}) \div 16$$

$$b_8 = (y_{11.25} - y_{33.75} + y_{56.25} - y_{78.75} + y_{101.25} - y_{123.75} + y_{146.25} - y_{168.75} + y_{191.25} - y_{213.75} + y_{236.25} - y_{258.75} + y_{281.25} - y_{303.75} + y_{326.25} - y_{348.75}) \div 16$$

$$a_7 = (y_0 - y_{25.71} + y_{51.43} - y_{77.14} + y_{102.86} - y_{128.57} + y_{154.28} - y_{180} + y_{205.71} - y_{231.43} + y_{257.14} - y_{282.85} + y_{308.57} - y_{334.28}) \div 14$$

$$b_7 = (y_{12.86} - y_{38.57} + y_{64.28} - y_{90} + y_{115.71} - y_{141.43} + y_{167.14} - y_{192.86} + y_{218.57} - y_{244.28} + y_{270} - y_{295.71} + y_{321.43} - y_{347.14}) \div 14$$

$$a_6 = (y_0 - y_{30} + y_{60} - y_{90} + y_{120} - y_{150} + y_{180} - y_{210} + y_{240} - y_{270} + y_{300} - y_{330}) \div 12$$

$$b_6 = (y_{15} - y_{45} + y_{75} - y_{105} + y_{135} - y_{165} + y_{195} - y_{225} + y_{255} - y_{285} + y_{315} - y_{345}) \div 12$$

$$a_5 = (y_0 - y_{36} + y_{72} - y_{108} + y_{144} - y_{180} + y_{216} - y_{252} + y_{288} - y_{324}) \div 10$$

$$b_5 = (y_{18} - y_{54} + y_{90} - y_{126} + y_{162} - y_{198} + y_{234} - y_{270} + y_{306} - y_{342}) \div 10$$

$$a_4 = (y_0 - y_{45} + y_{90} - y_{135} + y_{180} - y_{225} + y_{270} - y_{315}) \div 8$$

$$b_4 = (y_{22.5} - y_{67.5} + y_{112.5} - y_{157.5} + y_{202.5} - y_{247.5} + y_{292.5} - y_{337.5}) \div 8$$

$$a_3 = (y_0 - y_{60} + y_{120} - y_{180} + y_{240} - y_{300}) \div 6 - a_9$$

$$b_3 = (y_{30} - y_{90} + y_{150} - y_{210} + y_{270} - y_{330}) \div 6 + b_9$$

$$a_2 = (y_0 - y_{90} + y_{180} - y_{270}) \div 4 - a_6 - a_{10}$$

$$b_2 = (y_{45} - y_{135} + y_{225} - y_{315}) \div 4 + b_6 - b_{10}$$

$$a_1 = (y_0 - y_{180}) \div 2 - a_3 - a_5 - a_7 - a_9$$

$$b_1 = (y_{90} - y_{270}) \div 2 + b_3 - b_5 + b_7 - b_9$$

$$a_0 = y_0 - a_1 - a_2 - a_3 - a_4 - a_5 - a_6 - a_7 - a_8 - a_9 - a_{10}$$

In substituting the values for the ordinates in

the foregoing equations, care should be exercised in using the correct sign. The maximum ordinate c_n and the phase angle $\emptyset_n$ may be obtained from equations (3) and (4).

Frequently the curve to be analyzed has some type of symmetry in its wave form. This always is caused by the lack of certain harmonic components and recognition of this fact reduces the labor of analysis greatly. Examples of this may be found in alternating current waves which seldom contain even harmonics, and in certain cam motions which contain only cosine components. A preliminary study of the curve to be analyzed so as to determine the plan of attack well repays itself.

Analyzation of Valve Motion

For an illustration of the practical application of a harmonic analysis, the poppet valve motion shown in Fig. 4 may be taken. As this curve is symmetrical, it is plotted so as to start at the mid-point of symmetry, that is, at the point of maximum valve lift. This will eliminate the sine components and therefore reduce the analysis by one half. A large part of the curve is on a horizontal line during the valve closed interval and this is taken as the base line so to make all ordinates between 60 and 300 degrees equal to zero. Making an analysis of this curve for the harmonics from the tenth to the fifth we obtain;

$a_{10} = (.500 - .447 + .264 - .025 \ldots\ldots - .025 + .264 - .447) \div 20 = + .0042$

$a_9 = (.500 - .434 + .206 \ldots\ldots + .206 - .434) \div 18 = \ldots\ldots + .0024$

$a_8 = (.500 - .415 + .136 \ldots\ldots + .136 - .415) \div 16 = \ldots\ldots - .0036$

$a_7 = (.500 - .387 + .051 \ldots\ldots + .051 - .387) \div 14 = \ldots\ldots - .0123$

$a_6 = (.500 - .341 \ldots\ldots - .341) \div 12 = \ldots\ldots - .0152$

$a_5 = (.500 - .264 \ldots\ldots - .264) \div 10 = \ldots\ldots - .0028$

The value of these harmonics is a measure of the intensity of vibration they will produce in the spring which restrains the follower against the cam. If the spring in this case has a natural frequency of say 20,000 vibrations per minute, then it will be resonance with the tenth harmonic at a cam speed of 2000 revolutions per minute. This is due of course to the fact that the tenth harmonic produces ten impulses per revolution of the cam, or at 2000 revolutions per minute it produces 20,000 impulses per minute, which is the frequency of the spring. Thus the resonant speed with any harmonic is the spring frequency divided by the order number of the harmonic, and in this case the resonant speeds are:

10th harmonic = 2000
9th harmonic = 2222
8th harmonic = 2500
7th harmonic = 2857
6th harmonic = 3333
5th harmonic = 4000

If the spring be observed while the cam is rotated at speeds from 2000 to 4000 revolutions per minute, a surge, or spring vibration, will be noted at each of these resonant speeds, the most violent occurring at 3333 revolutions per minute and then in order of intensity the speeds will be 2857, 2000, 2500, 4000, 2222 revolutions per minute, according to the harmonic analysis given. It may be thought that the higher the speed, the greater will be the spring vibration and in a general way this is true. It does not follow necessarily, however, that as the speed is increased each resonant vibration will be greater than the preceding one, as is shown above where the vibration at 4000 revolutions per minute actually is less than at 2000 revolutions per minute. These speeds used for illustration are somewhat higher than generally are encountered in actual practice and to find the spring vibrations occurring below 2000 revolutions per minute for this particular case it is necessary to make a more complete harmonic analysis starting at say the 20th harmonic.

A study of this phenomenon has been made on equipment especially designed for this purpose, and photographic records of actual spring vibration have been taken which demonstrate the relationship with harmonics. Figs. 2 and 5 are views of this machine. For further information reference may be made to the article by Jehle and Spiller noted in the bibliography.

Applications Are Widespread

As harmonic analysis is a general method for dissecting anything of vibratory nature such as sound, alternating electricity, pulsating pressures and mechanical movements, its knowledge, besides broadening the grasp on some of the more difficult phases of engineering can be made a useful addition to the repertoire of the alert designer.

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IN OUTLINING the compounds which have a detrimental effect on leather in the article on "Protecting Bearings With Oil Seals," on page 30 of the August issue of MACHINE DESIGN, it was stated erroneously that mineral oil has a detrimental effect on leather. Mineral oils should not have been included in the classification given, as the success of leather oil seals is based upon their ability to withstand oils of this type.

"I venture to say that if one tenth of the money which has been lost in this depression had been put into a wisely planned program of research, the other nine tenths would never have been lost".—Karl T. Compton, in *Industrial Bulletin,* of Arthur D. Little Inc.

Predicting Worm Gear Efficiency Easily and Accurately

By H. J. Watson

SOME interesting facts on the inadequately known subject of gear efficiency were given in the article entitled "Modern Gear Efficiency" by W. H. Himes, which appeared in the February and April issues. Dealing with worm gearing, Mr. Himes accurately describes it as "the most controversial class of all gearing" and his remarks on the subject prompt the following notes since it may be of interest to add to his treatment of worm gear efficiency some of the general principles effecting this which experimental work in England has revealed.

Using the formula for efficiency given in the articles in question, Fig. 1 shows a family of curves for a range of possible coefficients of friction, while in Fig. 2 is given the coefficient of friction as it varies with the rubbing speed when using a case-hardened, ground and highly polished steel worm mating with a bronze wheel and lubricated with a mineral oil. By the use of these two graphs the efficiency of any worm gear may be predicted easily and accurately provided that particulars of the worm are known.

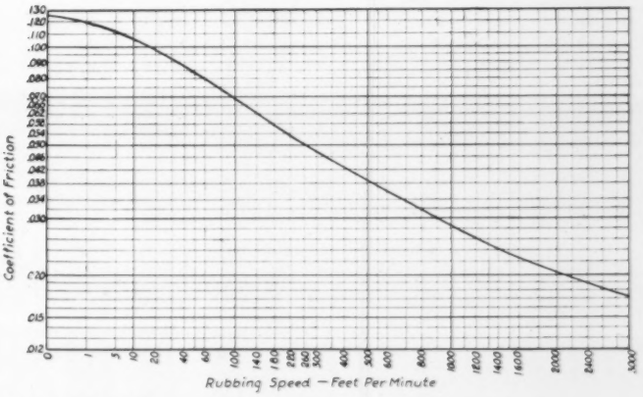


Fig. 2—A steel worm mating with a bronze wheel has a coefficient that varies with the rubbing speed as shown

Fig. 2 is the result of the work of Dr. Henry E. Merritt, chief of the David Brown research organization, and has been devised from many hundreds of tests. It shows how the coefficient of friction varies with the rubbing speed from the static value of 0.125 to 0.019 at 2400 feet per minute, and explains the increased efficiency of a gear when running at a high speed over its value when running at a low speed. The rubbing speed is a function of the lead angle and hence is dependent on the design

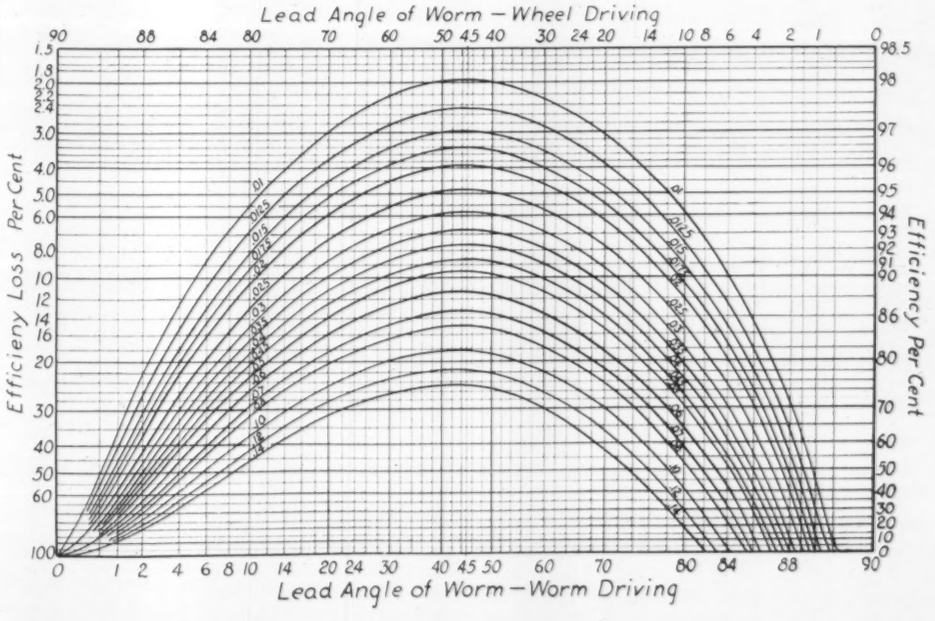


Fig. 1—Family of curves for a range of possible coefficients of friction

of the worm to some extent. It is obtained from the formula:

$$Rubbing\ speed = \frac{0.262\ d\ n}{\cos \lambda}\ feet\ per\ minute$$

where d and n are the pitch diameter and speed respectively in revolutions per minute of the worm and λ is the lead angle.

In regard to other conditions governing the coefficient of friction the most important is the type of lubricant. The effect of different oils is to increase or decrease the coefficient found from the graph readings according to the kind used. The curve illustrated is based on the heavy cylinder types of which 600W is a fair example. A castor oil gives readings approximately 20 per cent less than these throughout the range of the graph and while some of the blends of mineral oils on the market may give a coefficient slightly less than that shown, the improvement is not of much consequence. On the other hand, oils of low viscosity at the normal running temperature of the gear give readings considerably higher. It was found that the coefficient varied slightly with the viscosity and for this reason the tests were made at a temperature of 160 degrees Fahr., this being the approximate temperature at which a worm gear runs in normal circumstances.

Alloy Steel Is Employed

The best combination of materials was found to be a 3½ per cent nickel case-hardened steel worm and a straight bronze wheel containing up to 13.5 per cent tin and up to 0.1 per cent phosphorus. By altering the proportions of the tin and phosphorus a variation in the coefficient was marked quite definitely. The addition of other elements to give extra strength tends to increase friction but ample strength and wear resisting properties were obtained by using the straight bronze. Wheels are cast centrifugally since by this means the ultimate strength and wear resistanc of the alloy are increased by about 25 per cent. A variety of steels was used in the experiments but the 3½ per cent nickel steel case-hardened, ground and highly polished gave optimum results.

To some extent the surface stress in the teeth in contact has an effect on the coefficient in that it is increased slightly as the stress increases but in the experiments made for deriving the graph the maximum allowable working stress in the bronze was taken as the basis and little variation in the coefficient is found for variations of stress round that point.

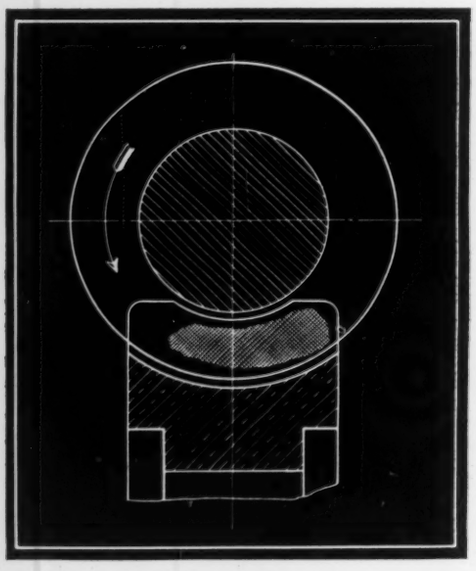


Fig. 3—Proper contact area for a worm gear as it mates with a wheel

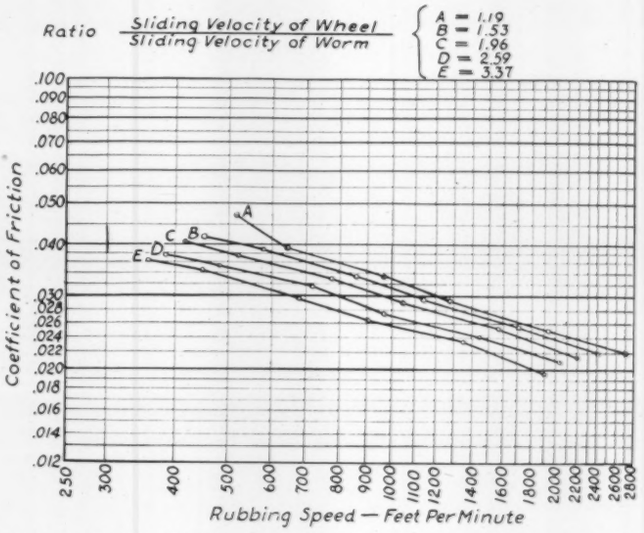

Ratio Sliding Velocity of Wheel / Sliding Velocity of Worm
A = 1.19
B = 1.53
C = 1.96
D = 2.59
E = 3.37
Coefficient of Friction
Rubbing Speed — Feet Per Minute

Fig. 4—Ratio of velocity with which worm slides over the wheel and vice versa as it affects coefficient of friction

In addition to the direct effect of the rubbing speed on the coefficient of friction the tests revealed a variation in the friction with the relative sliding velocity of the worm with the wheel. In a worm gear the actual sliding velocity is the algebraic sum of two velocities. The worm slides over the wheel and vice versa, and the ratio of these velocities varies according to the design of the gear. The effect on the coefficient of altering this ratio is seen in Fig. 4. The curves were obtained from the mineral oil of 600W type and are typical for this class of lubricant. The ratio of the relative sliding velocities of the wheel and the worm for each curve is:

$A = 1.19$
$B = 1.53$
$C = 1.96$
$D = 2.59$
$E = 3.37$

Fig. 2 follows the approximate mean value of similar families of curves.

It was noted that for corresponding conditions a castor base oil increased the spacing between

(Concluded on Page 72)

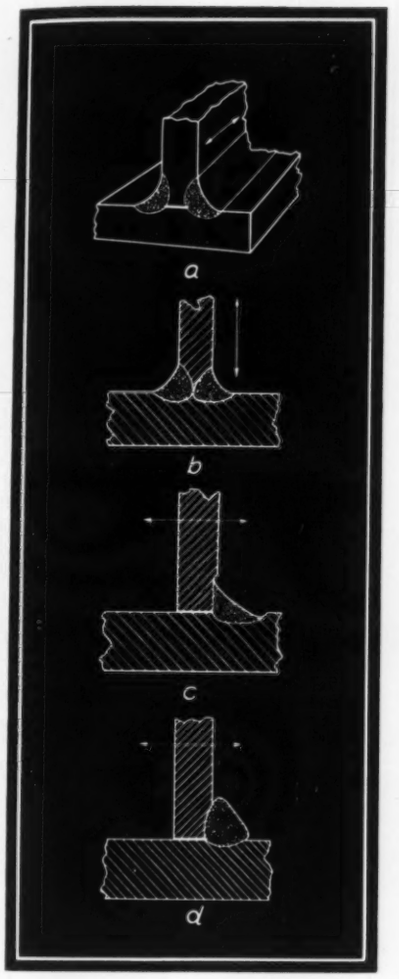


Fig. 1—Method of applying welds should be controlled by direction and amount of stress

Stress Determination Is Imperative in Welding Design

By Robert E. Kinkead

THE first consideration in the design of a welded steel assembly for use as a machine part is the determination of direction and magnitude of loads which are to be applied to the part. This constitutes a three-dimensional force problem familiar to all engineers responsible for design. In the light of present day thought, the problem perhaps should be expanded into a four-dimensional problem since the designer is concerned not only with the direction and magnitude of forces but also with the number of times such forces will be applied to the assembly during its service life. The fourth dimension in this case is time, and the designer immediately becomes involved in such matters as impact resistance, fatigue resistance, corrosion fatigue, etc. The first consideration therefore is one of static loading, and the second consideration one of discounting, if necessary, the behavior of the assembly under static loading by some amount which depends on what is likely to happen to the assembly during its entire service life.

Various methods are in use for the measurement and prediction of stresses at given points in an assembly under service loading. By far the most practical, from the designer's point of view, is the actual measurement of stresses of a similar part under service loading. This may be done by the application of suitable strain gages. Ordinary methods of calculation are applicable to simple beams, columns, and trusses, but beyond these uses mathematical calculation becomes laborious and subject to quite serious error.

Where the assembly is of entirely new design, use of photoelastic methods of stress analysis, scale model loading with strain gages applied and other similar methods are very valuable. The designer, in this connection, is confronted with the problem of costs. He always can apply a large "factor of ignorance," but many cases are on record in which it would have been much less expensive to have obtained the facts.

DESIGN of welded structures is similar yet totally dissociated with design for other methods of fabrication. Mr. Kinkead, consulting engineer, Cleveland, brings out some of the pitfalls in the path of a designer planning to use welding. He recommends that the design be made to accommodate the stresses without reference to method of fabrication, and the welds be placed later.

It is more important in welded steel assemblies than in the case of castings to find out what the stresses are likely to be. The cost of a casting increases roughly as the first power of its weight for relatively small increments of weight. In a welded steel assembly the cost increases roughly as the 1½ power of the weight. The reason is simple. For the most part welded steel assemblies are held together by fillet welds which increase in cost about as the square of the throat dimension of the fillets. Heavier material requires larger fillets so that the overall cost increases much more rapidly than the weight increases.

It is convenient to design the welded steel assembly along the lines indicated in the foregoing, determining the shape and thickness of the parts without reference to welding. Location of the welds and such matters as forming the material may be determined later within the frame work of the design.

Applying Welding to the Design

What the designer will have produced by following the methods referred to is fundamentally the same as if he had started out to design the job to be made of a casting except that the elements of foundry practice involving drawing of the pattern, shifting of the cores and probable defects in the casting have not entered into the solution. Now the designer finds himself confronted with the problem of how to form the plate economically, where to put the welds, and how to assemble the job without leaving the welder on the inside with no way to get out.

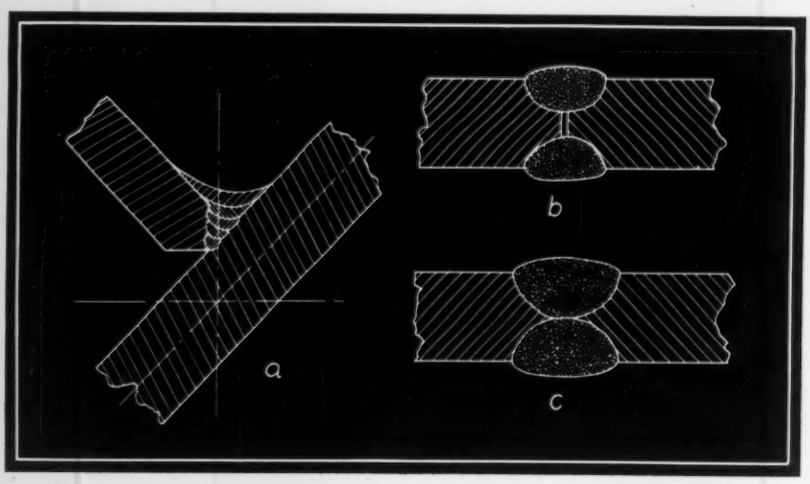


Fig. 2—For static loading weld shown at b would be suitable, while for repeated stress the weld shown below is best

Cold and hot forming of steel is a craft which covers a good deal of territory and cannot be treated with due consideration in this short article. The best thing the designer can do, if he is not familiar with the subject, is to get information from someone who has had experience in the work. This fact may be remembered however, it usually costs less to form an edge than it does to get it by welding two pieces of metal together, and the formed edge has a much better appearance.

Under ordinary shop conditions the weld may not be as reliable as the original and unwelded material although it is quite possible to make it just as reliable. In some cases it costs less to put the welds where they do not carry maximum stresses. Maximum stresses usually are marginal stresses. It is advisable to keep the welds away from the margins and, where this is impossible, put the weld at the point of minimum marginal stress.

Position of Fillets Important

The position and contour of the weld fillets are of great importance in the assembly since if they are made properly, no discounting of the behavior of the assembly is necessary because of the fact that it is welded together.

Fig. 1*a* shows properly applied fillets for the top and bottom flanges of a beam. The important stresses are parallel to the fillets. The contour of the fillet in section should approximate the contour of a machined fillet. The sum of the throat dimensions of the fillets should equal the thickness of the vertical member.

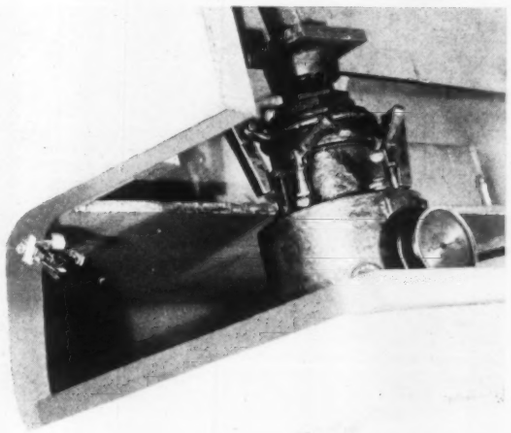
If, on the other hand, the load is perpendicular to one member, as shown in Fig. 1*b*, the fillets should meet at the center of the joint so that there is no unwelded portion of the joint. This would result in stress concentrations which might cause premature failure under repeated application of the load. Fig. 1*c* shows an improperly made fillet, due to undercutting, which would result in serious stress concentrations under the conditions of loading indicated. Another case is shown at *d* which is the kind of a fillet obtained where insufficient heat is used.

Fig. 2*a* illustrates the proper position for making a fillet weld in order to approximate the contour obtained in a machined fillet. It will be noted that the weld is put into the weld kerf in layers. With present knowledge, these layers should not exceed ¼-inch in thickness. This laminated structure is an important element of safety in welds since there is a remote degree of probability that a slight defect will be coincident in all layers.

Fig. 2*b* illustrates a type of butt welded joint which might be suitable for static loading in tension. It would, however, be likely to fail

prematurely under repeated application of the load due to stress concentrations around the unwelded portion at the center of the section. For repeated applications of the load, the type of weld section shown at *c* would be required.

Production men not only should know how to produce the welds specified by the designer, but also should be equipped adequately to do so. This involves equipment for handling the assembly so that the fillet welds may be made in the proper position, and facilities for mechanical stress relieving as well as for stress relieving in a furnace.



Courtesy, Lukenweld Inc.

Fig. 3—Test measurements may be made with hydraulic jacks and suitable strain gages

Weld metal applied to the assembly should have 60,000 to 70,000 pounds ultimate tensile strength and 30 per cent elongation as shown by a free bend test. Fillet gages are an advantage in providing that fillets of dimensions called for in the design will be produced.

It is of course true that there are a good many other matters of importance in the production of welded steel assemblies than have been mentioned here, but those mentioned are of particular significance to the designer.

Inspection Is Desirable

Inspection of important parts at the point of manufacture is desirable in many cases. Small defects may be corrected at slight expense in this way. Experience has shown that defects of design as well as construction are likely to occur and it is one of the advantages of welded steel assemblies that they may be corrected easily.

In the case of entirely new design it may be desirable to check stresses by application of static loads, measuring stresses by strain gages. This may be done with hydraulic jacks and suitable strain gages as illustrated in Fig. 3 which shows a press frame being checked.

Such testing and inspection will eliminate service failures due to application of normal service loading. Rolled steel has properties which are predictable to a satisfying degree of accuracy. There are no defects of such a nature as to produce surprise results.

Welded steel construction may cost more than the designer expects. In many cases, however, it will show savings in spite of high cost. Low costs come from volume production and from simplification of designs to save material and labor. From the responsible designer's point of view it is better to insist on safe methods of design and construction and compare the costs with other methods of fabrication than it is to permit the acceptance of low grade work merely because it is cheap.

Railway Cars Can Be Pre-Cooled

ARRANGEMENT whereby the air conditioning system can be plugged into an existing alternating current power supply in yards, thus cooling the cars before the train is started, distinguishes ten Westinghouse air conditioning units now being installed on cars of the Illinois Central railway system. The units, each producing a cooling effect equivalent to melting six tons of ice in 24 hours, consist of a self-contained high speed motor driven compressor and condenser mounted under the car body, similar to the familiar battery box. A gear driven axle generator, twice as powerful as the usual railway belt driven type, supplies power for car lighting, battery charging and the air conditioning system. While the car is being pre-cooled, batteries may be charged without change in connections. When the train is ready to leave the yards, the service is switched over from the alternating current to the direct current power supply carried on the cars. The electrical control is arranged to give constant voltage at any train speed from 20 to 90 miles an hour.

Air conditioning equipment operates on either alternating or direct current

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Although salaries and expenses of operation have been reduced drastically, no worthwhile new developments are being curtailed by General Electric, and engineering and research work which will provide new fields for the company in the future is being continued.

BERYLLIUM

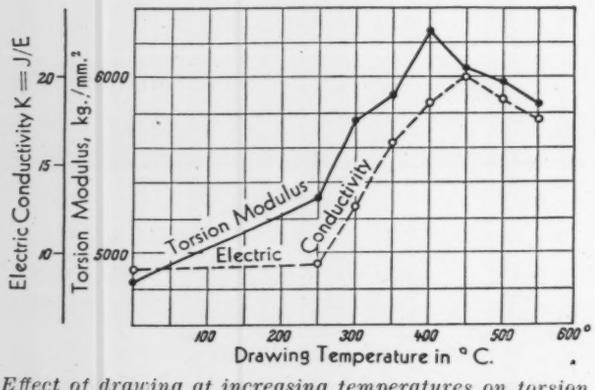
Its Production and Application in Design

KNOWN for more than 100 years, beryllium early held promise of becoming a valuable engineering material. It is one of the lightest metals, about one-third lighter than aluminum, and much more resistant to corrosion and chemical action. In the preliminary stages of its development it was costly and this factor to a large extent has stood in the way of its broad commercial application.

The cost, however, now has been reduced greatly and engineers are finding beryllium highly suitable for alloying with copper and other metals for industrial use. The marked reduction is the cost of production in recent years has been due in a great measure to the research work carried on by Siemens & Halske in Germany. A series of reports from the electrochemical division of this organization and from the research laboratory of Siemens-Konzern have been compiled into a book titled *"Beryllium, Its Production and Application."*

This comprehensive monograph is attracting wide attention. It merits the keen consideration of designing engineers who wish to know more about the properties and applications of the unique metal and its alloys. Of interest in an early chapter is the statement that the pronounced brittleness of technically pure beryllium bars its use as an unalloyed material.

Dr. Kurt Illig, one of the collaborators in the volume, refers briefly to the multiplicity of applications. In airplane construction, for instance, specifications call for suspension springs for the landing gear which are capable of resisting the impacts often experienced on landing. It appears that no other material is as adaptable for this purpose as an alloy containing the proper proportions of copper and beryllium heat treated after mechanical working.



Effect of drawing at increasing temperatures on torsion modulus and conductivity of 2.5 per cent beryllium copper alloy

Parts of electrical motors and internal combustion engines which are subjected to fatigue and reversal stresses constitute another important field for this material. Special tests have shown that beryllium alloys are suitable for producing such machine parts in one operation by means of pressing, which hitherto could be produced only from materials not susceptible to such treatment. A similar alloy containing 1 per cent beryllium and the balance copper has been found highly useful as a slip ring material.

In the accompanying diagram is shown the effect of drawing at increasing temperatures on the torsion modulus and conductivity of a 2.5 per cent beryllium copper alloy. For these measurements a number of wires made at the same time, treated in the same manner, were heated at different temperatures.

High Temperature Lowers Torsion Modulus

When wires quenched from 800 degrees Cent. are drawn at increasing temperatures a marked increase in the torsion modulus is obtained, and it reaches its maximum after being heated 30 minutes at 400 degrees Cent. When wires are heated at higher temperatures the torsion modulus again drops. The change in electrical conductivity practically parallels that of the torsion modulus as shown in the diagram.

Investigations disclose that beryllium has shown no noteworthy physical properties as an alloying component in the lighter metal alloys. This, however, does not detract from its value as an engineering material but suggests that the engineer before reaching any decision in applying it make a thorough study of its properties as an alloy from some reliable source such as the aforementioned book. Chemical Catalogue Co. Inc., New York, is distributing the English translation in this country at a price of $10. It may be obtained through MACHINE DESIGN.

Improving Design with New Finishes

By William J. Miskella

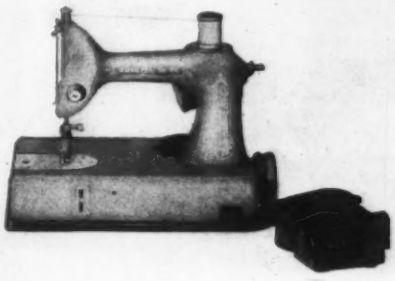


Fig. 1—(Left)—Portable sewing machine finished with glyptal lacquer. Fig. 2—(Above)—Sheet steel stand finished with synthetic lacquer harmonizes with porcelain tub

IN THE last few years manufacturers of finishing materials, paint experts and chemists have accomplished a great deal in the development of various kinds of protective and decorative materials suitable for "dressing up" machines. Collaboration with engineers responsible for design should result in utilizing all these accomplishments to the greatest possible advantage.

In the article on page 41 of the November, 1930, issue of MACHINE DESIGN, it was pointed out that crystal and crinkle finishes were filling the demand at that time and particularly were they supplying the need for an attractive one-coat finish which could be applied with ease by ordinary spray painters. These novel finishing materials are available, however, in a limited number of colors confined largely to the dull blacks and a few browns—not a very cheerful presentation to select from to say the least. Yet crystal and crinkle finishes still play an important part in the finishing of machines made of rough castings.

Research laboratories of paint and lacquer organizations have created several new and extremely important colored one-coat finishing materials within the last few years, and it is the properties of these which will be reviewed in the following. Unfortunately there has been another confusing term added to the already pretentious list of misleading ones used in finishing material nomenclature. This term is "synthetics."

Therefore it would be well for the machine designer who is interested specifically in any of the new finishing materials to learn from the manufacturer just what properties his materials possess, being careful not to get them confused, and also to consider prices and covering power jointly and not separately.

The drying of synthetic lacquers is governed by four principal factors: Evaporation, oxidization, thermosetting and polmerization. The first three are more or less self-explanatory, but the last one—polmerization—being rather a new term needs a little explanation.

Many paints, varnishes and enamels produced in the past have been mere mechanical mixtures of the raw materials used, as proved by the settling out of the solids in paint cans or other stock containers. Polmerized materials do not do this because a chemical change takes place within the materials which creates another sub-

TABLE I

Comparative Properties of New Finishes

Item	Four hour varnishes	Glyptal lacquers	Film-forming finishes	Baking lacquers
Drying Characteristics	Evaporation Polmerization	Evaporation	Polmerization Oxidization	Thermosetting
How dried	Air Force Bake	Air Force	Air Force Bake	.... Bake
How applied	Spray Brush Dip	Spray Brush Dip	Spray Brush Dip	Spray ....
Resistance to abrasion	Good	Excellent	Fair	Good

stance entirely, thus preventing the separation just mentioned. This new material, when once created, cannot be broken down.

Synthetic phenol-resinoid varnishes, or four-hour varnishes, are oleoresinous varnishes of this type. The resins embodied are made from

Fig. 3—Acid resisting porcelain enamel on sheet steel is efficient finish for this ironer

carbolic acid and formaldehyde. They resemble natural resins in appearance, but chemically are radically different because of the application of heat in the manufacturing process. It should be understood that the formulas for these varnishes include both the natural resins which have been used for many years in old type varnishes and some of the phenol resins. The chief characteristic improvement over the old slow drying varnishes has been quick drying.

Materials Have Better Adhesion

Although like ordinary nitrocellulose lacquer in appearance, the coating materials included in the glyptal lacquer classification are in a way analogous to ordinary varnishes and four-hour varnishes. They differ from ordinary nitrocellulose lacquers only by the addition of a new synthetic gum, called glyptal, made from glycerine and phthalic anhydride. Its presence in lacquer formulas gives the various materials two important properties—improved gloss and much better adhesion. Also, it makes possible the production of clear lacquers which will withstand the ravages of ultraviolet radiation and thus withstand exposure to the action of the sun.

Glyptal lacquers might be considered as air drying materials which take advantage of the physical properties of glyptal gums, while in the film forming finishes will be found an entirely different property which is not at all like previous kinds of finishing materials. Instead of drying by evaporation they are baked, which means dried by a combination of oxidization and polmerization.

Thermosetting, or baking, lacquers are the latest development in the finishing field. They must be subjected to heat in order to be cured. In fact they are related closely to the plastic molded bakelite products and may be looked upon as liquid forms of these materials.

Baking lacquers do not become brittle with age and they do not break and check or crack when turned on sharp edges. As a rule they are baked either at 200 degrees Fahr. for three hours or at 300 degrees Fahr. for 20 minutes. They contain no oil so cannot be classified as varnishes, are unaffected by organic solvents, and must be applied in one coat only. The spray method of application is at present the only way of handling this coating material.

One of the newest and most unique finishes

Fig. 4—Office equipment is excellent field for synthetic phenol-resinoid varnishes

that has received considerable prominence by its use on Graham-Paige and Rockne automobiles is pearl essence. The "transparent pigment" furnished to lacquer by adding a small amount of a substance to give it a beautiful irridescent sheen forms the basic property of this member of the finishing material family. This substance is a development resulting from the manufacture of artificial pearls. It is made from the crystaline guanin taken from beneath the scales of certain fish—not from the scales themselves.

The chief merits of this finish are depth of color and brilliance. Being of an organic origin there is no danger of toxicity or of corrosion. The finish may be had in a variety of color effects produced by combinations of a colored lacquer background or undercoating and a final coating of pearl essence lacquer through which the color of the undercoat reflects, thereby giving the sensation of "depth" to the surface.

Vaporization Protects Heating Units

By H. F. Shepherd

WHEN electric heat is applied to machines a delicate balance must be established between energy input on the one hand and heat absorption into product plus heat losses by conduction, radiation and convection on the other. This balance may be upset by allowing the machine to run without doing useful work, by irregularities in the electric potential, or by atmospheric conditions.

If the heat input exceeds the output ever so slightly when conditions are such that radiation does not re-establish a balance at a slightly higher temperature, heating becomes cumulative and the apparatus may be burned out. Often it is desirable to design the heating element so that it reaches the required temperature in a short interval of time, as in one minute after turning on the current. This in itself requires limited conduction and radiation if the energy consumption is to be moderate. Consequently, some means of control must be supplied to check the rise of temperature at a desired or safe limit.

Relays Are Required

Thermostats and thermocouples are available for this purpose, but the effects of these are so graduated that it is not very practical to operate directly on the main current input, a relay being required to make and break the circuit positively at the main contactors. This complicates the system if there is little room at the points of heat application for thermostatic elements or thermocouples.

A problem of this sort arose in the design of low pressure oil engines which require preheating for starting. The heating element was required to reach the starting heat in one minute and it was quite desirable that a few minutes delay or complete failure of the operator to shut off the current should not cause the heating element to burn out. No design of naked resistance element would meet this requirement.

The solution was found in the disposal of excess heat by condensation of the vapors of a liquid surrounding the heating element. The resistor was made of sheath wire which lends itself admirably to the purpose. This, a patented product of General Electric Co., is made by centering a Nichrome rod in a piece of seamless tubing after which the annular space is filled as densely as possible on a jarring table with dessicated lime or other suitable insulator.

Ends of the tube are closed with washers and the whole is then swaged, by repeated passes in rolls, to the required form. This at once reduces the gage of the resistance wire, compacts the insulating material and reduces the diameter of the enclosing tube. The resulting product is a resistor surrounded by a fireproof insulator and enclosed in an impervious metal sheath.

For oil engine work this resistor, 1 Fig. 1, wound into a coil, was immersed in a mercury bath 2. When the temperature of this bath reached 360 degrees Cent., which was sufficient for the purpose, the mercury boiled and the vapors rose to the condenser 3, above, which was either air or water cooled. Condensation of these vapors and their return to the bath

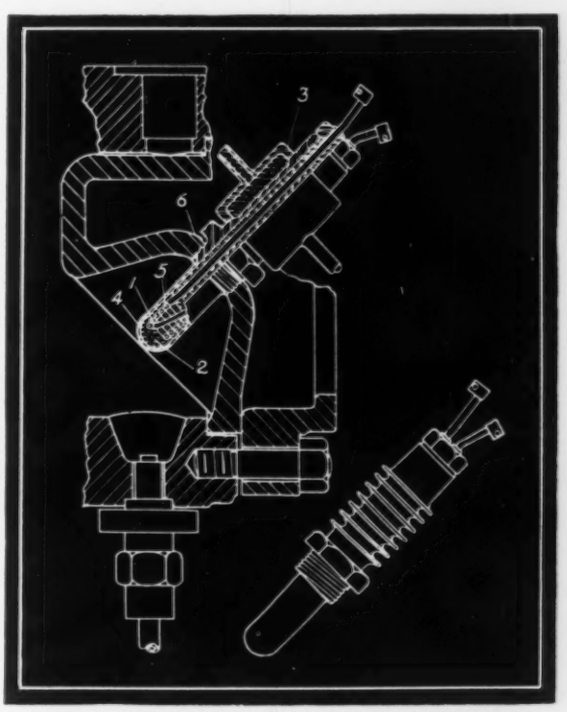


Fig. 1—Electric heating unit employs liquid vaporization to prevent burnouts

served to maintain a constant temperature at the working end of the unit.

To limit heat losses due to conduction, shell 4 was made quite thin and the liquid level 5 was kept well below the attachment thread 6. Low voltage current was used in order to allow use of a stout resistor. This is made available at little apparatus cost by use of an auto transformer of the type used for sign lighting.

Sulphur Is Available Medium

For temperatures other than 360 degrees Cent., other mediums are available as any handbook of physical tables will reveal. Among these is sulphur boiling at 446 degrees Cent. At this temperature it sulphides rapidly and destroys all metals except aluminum which seems to survive well. Where it is not possible to use aluminum parts, as for instance, for the sheath wire, careful calorizing seems to preserve steel as well. This is preferable as it is to be noted that aluminum alone has little strength at 446 degrees Cent.

In the use of petroleum products for a medium, care should be exercised to avoid those which are unstable and prone to crack into other hydrocarbons, carbon and gas when slightly superheated. This applies to the heavier fractions boiling above 250 to 300 degrees Cent.

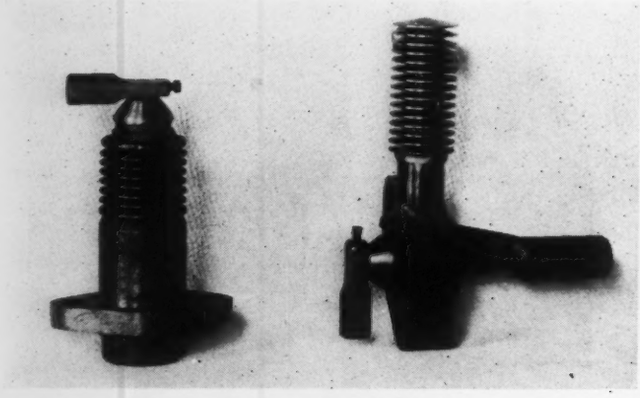


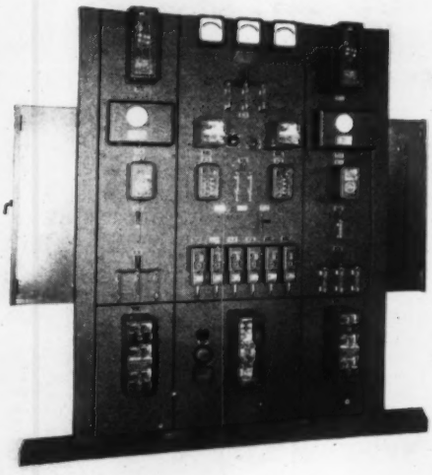
Fig. 2—In both vertical and horizontal designs, condenser must be elevated above heating element

Water is useful for the lower temperatures and either water or mercury may serve over a wide range by maintaining a definite air pressure in the condenser. This has been done successfully in a number of cases.

Fig. 2 shows vertical and horizontal designs. The condenser must of course be elevated, but there is no practical limitation to the distance between condenser and heating element. Naturally there is some waste of energy as long as the condenser is working, but careful design will minimize this loss.

Audible Reports on Station Status Are Given Automatically

BY MEANS of special audible indicating equipment, operators can obtain reports of the conditions in new Maryland pumping stations from any point which has telephone connection with the station. The pumping station number is dialed in the usual manner, and the indicating equipment designed by General Electric engineers is set into action immediately. The desired information is transmitted by means of a series of codes made up of long and short buzzes heard in the telephone receiver.



Equipment reports station status automatically

Different codes are separated by a single stroke bell signal.

The equipment tells whether or not conditions generally are satisfactory and correct at the station, which of the two pumping units is selected as the preferred one, whether water is flowing into or out of the reservoir, what the water pressure is, and what the water level is in the reservoir. If the first report shows that the station is not in satisfactory operating condition, then an additional set of codes is transmitted indicating whether or not voltage is available for each of the pumping units and whether or not either unit is out of service.

When the audible equipment is once started, it proceeds to report on all the various conditions and then repeats the signals as a check. If, however, someone is visiting the unattended station and wishes to answer the telephone, he may do so without interference with the indication equipment because it is disconnected from the telephone as soon as the receiver is lifted.

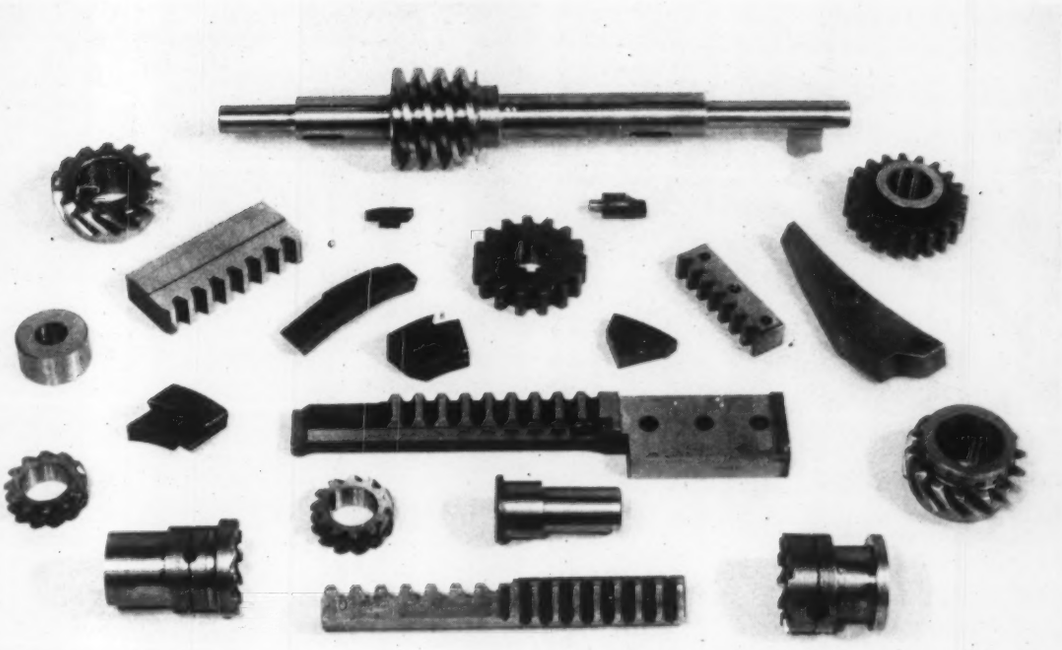


Fig. 1 — Alloy carburizing steel with 3.40 to 3.80 per cent nickel used for worm, helical and spur gears, racks, etc.

Improved Materials Permit Speedier Operation

By D. B. Bullard

CUTTING tools in industry have marked several epoch-making phases which have required redesigning or the development of new design of machine tools to take advantage of the greater possible cutting speeds. These developments naturally have resulted in the use of more powerful motors and greater structural rigidity to eliminate vibration and care for increased stresses and strains. Huntman's development of crucible tool steel was perhaps the first big step. Low alloy steels of the Mushet type permitted higher cutting speeds. Taylor's classic development of the heat treatment and composition of high speed tool steel revolutionized the industry.

Later changes in composition and refinements in methods of manufacture gradually have permitted higher and higher cutting speeds. The use of base materials other than steel, such as Stellite and, more recently, tools tipped with cemented carbides of tungsten and tantalum which have extreme hardness and stability under heat, has been a notable factor under certain machining conditions. Due to the mechanical characteristics of these new cutting materials, it has been found that the best results are secured under different cutting conditions than is the optimum for high speed steel so that instead of a relatively slow speed and heavy cut removing the maximum amount of metal per minute, a higher speed and lighter cut is found desirable. The end of this development has not yet been reached, and the machine tool builder must anticipate a combination of both high speeds and heavy feeds.

The newer Mult-Au-Matic developed by The Bullard Co., is designed to meet not only today's conditions, but those which may develop in the next decade. With antifriction bearings of nickel-molybdenum steel and applications of

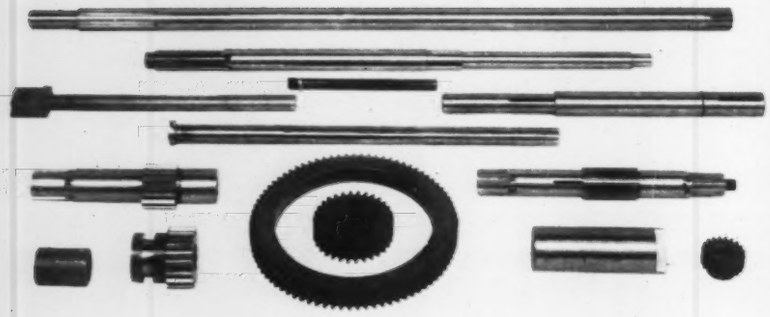


Fig. 2—Double quenching operation from high temperature gives best machining properties to material for shafts, feed rod, coupling and drive gear

other materials described in the following, the machine is capable of being driven at tremendous speed with an extraordinary development of power at the point of cutting.

In previous years machines of this type were driven by 10 to 15-horsepower motors, while today it is common to equip them with 25 to 35-horsepower motors. This increase of input power has brought forth a series of progressive changes in the use of gear materials. Although it was not necessary to increase physical dimensions of the formerly used cast iron gears to accommodate these speeds in all cases, it was believed expedient to introduce the use of higher grade materials even in those parts in order to promote longer and more efficient operating life. Therefore, the first development was to change from cast iron to steel. Then, with the advent of the new cutting alloys, came another progressive problem—again gear materials, and this time for higher speeds. Here the solution was found in the use of heat treated alloy steels.

Carbon steel shafts have been superseded by heat treated chrome-nickel steel in these machines, and ordinary cast iron in many parts has been superseded by high strength alloy cast iron. In a few parts this material has been improved further by heat treating to obtain a high tensile strength.

Alloy Steel Is Standard

Oil hardened nickel alloy steel is used extensively and has been adopted as standard for many heavy duty applications. After years of experimenting a steel was selected with a chemical specification similar to SAE-3450. The specifications have the following range: Carbon .45/.55; manganese .40/.70; silicon not over .30; phosphorus and sulphur not over .03; chromium .50/.90; and nickel 2.75/3.25. After forging, the material is normalized as follows: Heat to 1550-1580 degrees Fahr.; quench in oil; reheat to 1380-1400 degrees Fahr.; followed by a quench in oil. This material then is reheated to 1380-1400 degrees Fahr. and cooled slowly in the furnace. It has been found that the double quenching operation from the high temperature is essential to give the best machining properties, and that with this treatment no difficulty is experienced in drilling deep holes and obtaining a smooth finish. Parts made out of this material, Fig. 2, include: Spindle and main drive shafts; control gears; clutch pinions; drive gears; couplings; gear studs; clutch shafts; lock pins; change gears; and feed stop rods.

In numerous cases where an extremely hard surface is desired to yield the best wearing properties, a case hardened carburizing alloy steel is used. This material approximates SAE-3312, and has the following chemical composition: Carbon .08/.15; manganese not over .45; silicon not over .30; phosphorus and sulphur not over

TABLE I

Specifications Governing Heat Treated Alloy Cast Iron

Chemical Analysis

Total carbon	2.75-3.00%
Silicon	2.40-2.70
Sulphur	0.10 Max.
Phosphorus	0.10 Max.
Manganese	0.70-1.00
Nickel	1.30-1.75
Chromium	0.30-0.50

Mixture

Steel	94.00%
Ferro-silicon (90% Si.)	2.50
Ferro-manganese (90% Mn.)	2.00
F nickel shot	1.50 (Ladle addition)
Ferro-chromium	0.50 (Ladle addition)

Note: Ferrosilicon and ferromanganese are coated with cement before being placed in the cupola.

Physical Properties

Tensile strength, as cast	50,000-55,000 lb./sq. in.
Transverse strength, as cast	5,000- 5,500 lb./sq. in.
Brinell hardness	212-240
Tensile strength, heat treated	70,000-75,000 lb./sq. in.
Brinell hardness, heat treated	286-340

Heat Treatment

Heat to 1550-1600 degrees Fahr., quench in oil or water and temper to brinell hardness of 286-321 (850-950 degrees Fahr.).

Note: The section heat treated governs the selection of the quenching medium—heavy sections being quenched in water, while the lighter sections may be oil quenched.

.03; chromium 1.25/1.75; and nickel 3.40/3.80.

Whether made from bar stock or forgings, the parts are normalized before machining by heating to 1400 degrees Fahr., cooling in air, followed by heating to 1250-1280 and cooling in the furnace. The carburizing operation consists of heating to 1600-1650; minimum depth of case specified is .025 to .030. In many parts the actual depth is .040 to .050. The parts are cooled in the box, but arranged so that they will get a free flow of air to hasten cooling. This prevents the formation of any carbide net work in the case. They are hardened by heating to 1525-1575, quenching in oil for refining the core, and

TABLE II

Results of Typical Heat of Cast Iron

Tensile strength, as cast (Ave. of 3)	58,153 lb./sq. in.
Transverse strength, as cast (Ave. of 6)	5,161 lb./sq. in.
Tensile strength, heat treated (Ave. of 3)	81,053 lb./sq. in.
Brinell hardness, as cast	240
Brinell hardness, heat treated	321

Note: Heat treated hardness may run from 320-340 if desired.

Chemical Analysis

Combined carbon	0.50%
Graphitic carbon	2.25
Silicon	2.41
Sulphur	0.097
Phosphorus	0.031
Nickel	1.80
Chromium	0.42

1375-1425 in oil for refining the case. The drawing temperature is between 280-300. The parts are file tested and usually show between 60-62 Rockwell "C" hardness. On some parts a single treatment which consists of heating to between 1400-1450 and quenching in oil is used. Typical parts, Fig. 1, made of this material are: Clutches, traverse spiral gears; dogs; cam roll studs; heavy duty washers; plungers; rack pinions; feed racks; and feed worms.

Bases of the machine are made of plain iron containing about 25 per cent steel. They have a tensile strength around 30,000 pounds. These parts are not subjected to wear, and the design is such that a higher strength iron is not necessary. This iron in conjunction with the design of the bases seems to be well suited for dampening vibration.

However, high strength alloy iron is used not only in the as-cast condition, but is improved further by means of a heat treatment. The use of heat treated alloy cast iron is a pioneer development in the machine tool industry, its previous application being confined to drawing dies in the automotive industry and cylinder sleeves in England. It is made to the specifications shown in Table I.

As quenched, or with a low drawing temperature, the tensile strength of the iron is somewhat less than the iron in the as-cast condition. The hardness, of course, is high. As the drawing temperature is increased the hardness decreases, but the strength gradually increases to a maximum secured with 850-950 degrees Fahr., corresponding to a brinell hardness of about 321. At this hardness the material can be machined without a great deal of difficulty. Tests on typical heats gave results shown in Table II.

Shows Good Wearing Properties

Whether the iron is used in the as-cast or the heat treated condition depends upon the type of machine and conditions under which the parts are to operate. Parts made of this heat treated iron, Fig. 3, include: Drill head spindle bodies and sleeves; saddles; gibs; swivels; tool slides; tool head guides; and brackets. This material shows remarkable wearing properties, especially in gibs and slides which may come in contact with the chips removed in cutting.

Higher speeds and feeds necessitate improved materials of construction. It is hoped the foregoing will be of some assistance to the field of design in indicating the specific practice of one of the larger manufacturers of metal cutting machinery.

Fig. 3—Typical parts made from nickel cast iron include saddle, slide, column, slide and saddle gibs. Material may be used as cast or heat treated

Editorial

"More and Better Machines" Is Logical Outlook for Future

IN MANCHESTER, England, cotton weavers have accepted a wage cut after striking to avoid it. The incident brings to attention the long decline in Lancashire cotton trade, which is due in part to the high cost of production in Manchester mills. Workers have resisted the installation of modern automatic looms. By this policy they retained their jobs temporarily, but caused their employers to lose trade to competitors equipped with more efficient machinery. In the end the workers are reaping the bitter harvest of their own misguided action.

Here and there in the United States counties and cities are awarding road work with a stipulation that it be done by manual labor. This simply affords temporary employment for unskilled workers at the expense of lowering the number of hours of work for skilled men in road machinery plants.

The enmity to machines reflected by these two incidents arises from the fact that during the past decade machinery has been adopted so widely and so rapidly that society could not keep pace in adjusting itself to the new conditions.

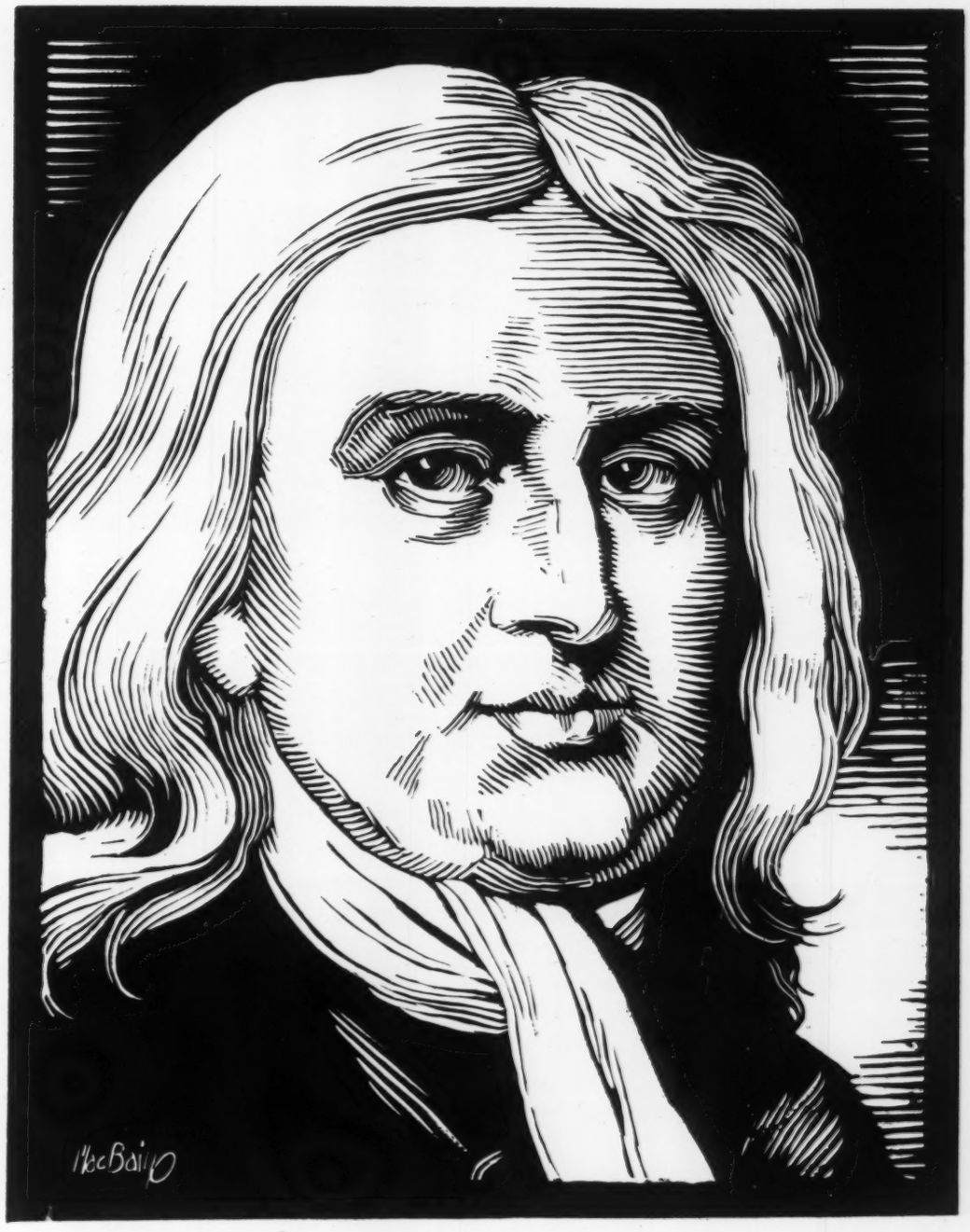
One American company has adopted a policy of making employment adjustments within its own plant. If a machine is installed which displaces several men, new products are developed to afford work for those forced out by the machine. This is a remarkable case of unit adjustment.

When the country as a whole finds a way to speed the realignment of jobs caused by "technological" unemployment, attacks on the "machine menace" will cease.

The Larger Market

BUSINESS transacted in the "necessity" class usually is considered as being small in comparison with that in the "luxury and convenience" class. Yet it is astounding to learn from an eminent engineer that the actual proportion is 15 per cent of the former to 85 per cent of the latter. These figures are based on accepted standards of living in this country.

With the impending increase in number of leisure hours and the inherently progressive raising of the standard of living, it is obvious that excellent opportunities for manufacturers or individual engineers to engage profitably in business lie in fields devoted to production of "convenience" or "luxury" items. Those engineers who can develop machines which although now apt to be considered in this class later may be regarded as necessities—witness the automobile and the typewriter—are in an exceedingly fortunate position.



Isaac Newton

Master Designers

Isaac Newton

NEVER did a scientist do less to promote general acceptance of his conclusions than Sir Isaac Newton, and none cared less for fame, yet the sheer worth of his achievements quickly brought him into prominence and caused him to stand out in bold relief in a group of philosophers distinguished by the number of brilliant men it included. He carried to perfection the art of correlating facts, of segregating the essential from the incidental and of deducing the laws of physical phenomena.

MAKING use of astronomical and mathematical theories evolved by his predecessors, Newton demonstrated the principle of universal attraction of gravity and formulated the rules for it. He invented the reflecting telescope, far better than any telescopic instrument previously devised, studied light and optics and performed the first spectrum analysis. He was the first to mark down the varying degrees of refrangibility for the rays of each color.

DIFFERENTIAL calculus is the invention of this great philosopher who also discovered the binomial theorem. His work in mechanics and in astronomy, which attracted considerable study, led to clear cut, usable expressions for the laws of motion; expressions of such value that these laws are known as a work of Newton's even though they were developed originally by Galileo.

NEWTON'S work was all but complete when he was 24, lacking only accurate data to demonstrate its accuracy. This man, born at Woolsthrope, England, 1642, never had any really youthful traits. Dreamy, shy, untidy, modest, he had no interests other than his scientific work and his professorship at Cambridge. He disliked controversies and was extremely irritable when contradicted. When he was 45, he received an appointment as officer of the Mint, and applied himself to this work to the exclusion of scientific investigation until his death at 85.

PROFESSIONAL VIEWPOINTS

Publication of letters does not necessarily imply that MACHINE DESIGN *supports the views expressed*

Comments and Questions from Our Readers. Machine Design Will Pay for Letters or Solutions to Problems Suitable for Publication

Eliminating Noise in Machines

To the Editor:

TOO much stress cannot be placed on the value of eliminating noise in machines as brought out in your recent series on this subject. The writer consistently has taken the stand that noise of any kind is inseparable from wear, and if this statement is accepted as axiomatic by a designer, he is well on the way to becoming a much more competent engineer. It is admitted readily that this is a rather strong statement, but experience over 25 years with the highest types of machine tools indicates that the subject has been given insufficient attention in the past.

The incidence of drum heads in castings, like the poor, is always with us, and only the rigid supervision of a competent designing engineer will eliminate this difficulty. Drum heads are a sign of rank amateurism among the designing fraternity. There are innumerable other potential sources of noise. Hydraulic circuits frequently offend on account of inadequate passages causing wiredrawing; relief valves of wrong design chatter and pound; geared pumps with eccentric gears also churn and pound.

The study of noise in machinery provides but another proof of the thought that engineering progress is a matter of circles and cycles, inasmuch as many vintage mechanisms produced by the designers of fifteen and twenty years ago with tools even at that time acknowledged to be crude are more silent in operation than the equivalent mechanisms of today.

—R. E. W. HARRISON,
Cincinnati

Patents Galore!

To the Editor:

ALTHOUGH an inventor may know that he has only one chance in a thousand to profit from his invention, as pointed out in the editorial in the September issue, he will take that chance. He will apply for a patent because he believes his invention will be *the one* out of the thousand. Warn him if you wish. Tell him that only twelve out of every 10,000 patents prove profitable. He still will think he has one of the profitable twelve.

Let me, however, issue a word of warning to inventors. It costs money to secure a patent to protect your invention, but it costs more money to insure the patents giving this protection. Therefore be sure that you are financially able, or that you have the backing of a well established company that is able, to go the limit if necessary to make your patent protect your invention.

—R. A. PERRETT,
Oak Park Ill.

Cubes and Cube Roots

To the Editor:

TO SIMPLIFY cubic computations and insure accuracy when using a slide rule, as was done for squares and square roots of large numbers, July, 1930, MACHINE DESIGN, I have developed the following procedure. Numbers will be referred to as consisting of two parts: The first part will be termed the base, the rest of the figures will be termed the balance.

The decimal point will be assumed to follow the first part of the number, and should be adjusted in the final result when located otherwise. Table of cubes up to 1000 will be used.

Cubes: To cube a number, find the cube of the first three figures, the base of the number, from a table. Now take the square of the base from the table, multiply it by 3, and on the slide rule find the product of this tripled square of the base and the balance as shown in the following.

Add the reading on the slide rule to the cube of the base and get the answer.

Cube of $859.375 = ?$

$$\begin{aligned} 859^3 &= 633{,}839{,}779 \\ (3 \times 859^2) \times 375 &= \quad 830{,}000 \\ \hline & 634{,}669{,}779 \end{aligned}$$

Cube Roots: To extract the cube root, point off periods as usual and find the largest root contained in the first three periods from the table (to locate the corresponding quickly first find it approximately on the slide rule). This gives the first three figures, the base of the root. Subtract the cube of the base as indicated in

the computations. Now from the table take the square of the base, multiply it by 3, and on the slide rule divide the remainder by this tripled square of the base. This will give the balance figures of the root.

Cube root of 634,669,700 = ?

$\sqrt[3]{634,669,700} = 859 + \text{Balance}$

634,669,700
633,839,779

829,921

$829,921 \div (3 \times 859^2) = 829,921 \div 2,213,643 = 375 = \text{Balance}$
$859 + 0.375 = 859.375$

Annex the balance of the base and get the answer, 859.375, accurate to six places.

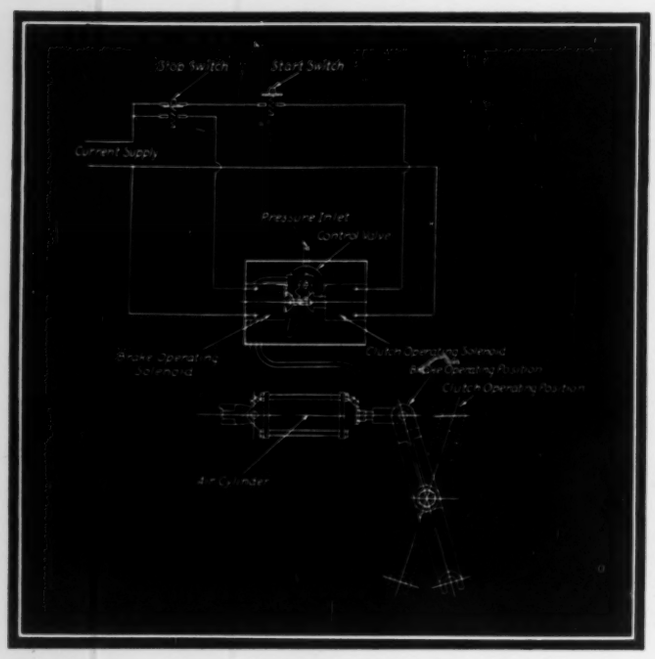
—B. W. BARISH,
Philadelphia

Electro-Pneumatic Controls Efficient

To the Editor:

THERE seems to be a strong aversion among engineers to pneumatic mechanisms, especially when coupled with electrical controls, and I also have doubted their practicability until recently. This change in attitude was brought about by development of a large power press, using compressed air for power control and operated electrically. The control embodies several features of advantage over hand-operated clutches and brakes.

The flexibility of a unit of the type shown in



Flexibility of electro-pneumatic mechanism is of great advantage as switch can be placed anywhere

the accompanying illustration is of great advantage because an electric switch can be placed almost anywhere without interference, and since the machine is operated from the front and the power control is at the back of the press no complicated system of levers is necessary. The press is started and stopped instantly by merely pressing an electric switch button. An extremely sensitive safety device and an automatic stop were installed by setting switches into the electric circuit.

Air cylinders of almost any bore and stroke may be purchased, and by pressure regulation the clutch may be made to operate gradually or instantly as in the case of a brake. The diagram shows the arrangement of the solenoids and the control valve. Switches are wired in such a way that the solenoids cannot be working against each other at any time.

A design of this type is quite simple, extremely flexible and economical. The machine referred to is proving most satisfactory.

—LLOYD A. WHITTAKER,
North Attleboro, Mass.

Standardize Screw Terminology!

To the Editor:

ONE of the most widely recognized inconsistencies in engineering today and yet one in which the profession, apart from the American Standards association, seems to make little, if any, endeavor to correct, is the use of names for simple screwed fastenings.

A glaring example is that of machine screws and slotted head capscrews, which overlap one another in the upper range of the former and lower range of the latter. In the first place, why not eliminate the overlapping of these so similar parts by taking machine screws up to $\frac{3}{8}$-inch and then following by capscrews of $\frac{1}{2}$ inch and over. The prime difference in the two styles of part was originally that the threads of machine screws were rolled and those of capscrews were cut by dies. Many so-called capscrews now have rolled threads, another argument for unification. Although so similar in appearance, there are minor differences in the sizes of the heads of machine screws and their equivalent capscrews but it would appear to be a comparatively simple task to adopt one set of sizes. Why should a roundhead machine screw become a button-head machine screw if its head is a few thousandths different in diameter and its threads are cut instead of rolled? In some quarters a fillister head screw is a round head, although this is straightened out in official circles. Examples of such inconsistencies could be cited without end, but the foregoing are typical.

Individual engineers can do much to get away from this "Engineering Tower of Babel" if they will insist on using terms as have been adopted by the American Standards association and by using their influence to obtain consideration by the association of such anomalies as indicated in this article.

As an afterthought on the subject of anomalies, why, in sizes below ¾-inch bolts in the American Standards regular nuts and bolts, is it necessary to have different sized hexagons and if necessary, why cannot they be consistently different? For instance, the hexagons of the bolts, capscrews, castellated and high nuts are alike for the 5/16, ⅜ and ½-inch but differ in the regular nut. Then in the ¼ and ⅝-inch sizes the bolt hexagon is the odd man out and the regular and castellated nuts and high nuts have the same hexagon. This causes confusion to the user.

Plain finished washers also are used frequently enough to warrant establishment of standards but the writer knows of none other than those set up for use in aircraft.

—W. S. Brown
Auburn, N. Y.

Scheduling Design Procedure

To the Editor:

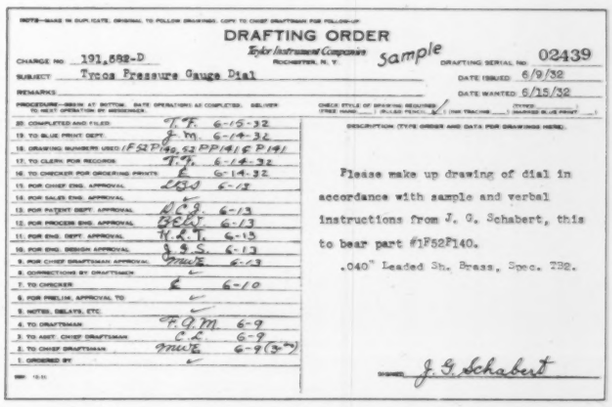
I AM of the opinion that although methods of handling orders received for execution in design departments differ according to the setup of the particular organization of each, fundamentally the various steps are common. Certain specifications are supplied by the engineering department from which drawings of layout, assemblies, sub-assemblies, details, etc. are to be prepared. Some form of requisition accompanies these specifications authorizing the department to perform the work of producing the drawings. The drawings are completed, necessary records and blueprints made and the order closed.

In small drafting departments the above procedure presents little difficulty, but in larger organizations where fifty or more projects are in progress, it is essential that the routine be controlled closely and recorded.

For this purpose, the form described in the following was developed and has been functioning well over a two year period. The writer of the order leaves the item entitled "Drafting Serial No." for the drafting department to fill in. The maker of the order enters the dates, style of drawing required and data for the drawings. When space does not allow the data to be entered the required material is clipped to the order along with any sketches, samples, etc. necessary. Both an original and a duplicate copy are delivered to the chief draftsman but an additional copy may be made and retained by the maker if he wishes a follow-up.

The chief draftsman reviews the order and data adding notes for any suggested procedure, retains the carbon copy and delivers the original with its papers to his assistant for scheduling and distribution to squad leaders or draftsmen. The duplicate is given to the record clerk who enters it in the numerical index book. In this book the orders are typed, consecutively, on transparent paper, giving the D. S. N. (Drafting Serial No.), the subject, date received, date out (when completed) and charge number. Each month, blueprint copies are made from these index sheets for the current orders and form comprehensive reports to the management on the volume and nature of orders passing through the department. The book also forms a permanent index for the file of completed orders.

After recording, the clerk files the duplicate


NOTE—MAKE IN DUPLICATE, ORIGINAL TO FOLLOW DRAWINGS, COPY TO CHIEF DRAFTSMAN FOR FOLLOW-UP

DRAFTING ORDER

Taylor Instrument Companies
ROCHESTER, N. Y.

CHARGE No. 191,582-D — Sample — DRAFTING SERIAL No. 02439

SUBJECT Tycos Pressure Gauge Dial — DATE ISSUED 6/9/32

REMARKS — DATE WANTED 6/15/32

PROCEDURE—BEGIN AT BOTTOM. DATE OPERATIONS AS COMPLETED. DELIVER TO NEXT OPERATION BY MESSENGER.

CHECK STYLE OF DRAWING REQUIRED (TREE HAND ___) (PULLED PENCIL ✓) (INK TRACING ___) (TYPED ___) (MARKED BLUE PRINT ___)

20. COMPLETED AND FILED	T. F.	6-15-32
19. TO BLUE PRINT DEPT.	J. M.	6-14-32
18. DRAWING NUMBERS USED	1F52P140, 52PP141 & P141	
17. TO CLERK FOR RECORDS	T. F.	6-14-32
16. TO CHECKER FOR ORDERING PRINTS	E	6-14-32
15. FOR CHIEF ENG. APPROVAL	LBS	6-13
14. FOR SALES ENG. APPROVAL	✓	
13. FOR PATENT DEPT. APPROVAL	RCJ	6-13
12. FOR PROCESS ENG. APPROVAL	BEW	6-13
11. FOR ENG. DEPT. APPROVAL	H. L. T.	6-13
10. FOR ENG. DESIGN APPROVAL	J. G. S.	6-13
9. FOR CHIEF DRAFTSMAN APPROVAL	MWE	6-13
8. CORRECTIONS BY DRAFTSMEN	✓	
7. TO CHECKER	E	6-10
6. FOR PRELIM. APPROVAL TO	✓	
5. NOTES, DELAYS, ETC.	✓	
4. TO DRAFTSMAN	F. G. M.	6-9
3. TO ASST. CHIEF DRAFTSMAN	C. L.	6-9
2. TO CHIEF DRAFTSMAN	MWE	6-9 (3-00)
1. ORDERED BY	✓	

DESCRIPTION (TYPE ORDER AND DATA FOR DRAWINGS HERE)

Please make up drawing of dial in accordance with sample and verbal instructions from J. G. Schabert, this to bear part #1F52P140.

.040" Leaded Sh. Brass, Spec. TB2.

J. G. Schabert

Carefully prepared drafing orders insure proper attention for design work as it passes through department

in a follow-up box held by the chief draftsman. They are filed in numerical order in this box but file signals are used to indicate their status. The original copy follows the drawings through their various stages of completion as shown by operations 1 to 20 printed on the form.

After the orders are completed and all records are cleared, the originals are punched and filed in books of 200 each for future reference according to the numerical index book mentioned previously. The duplicate copies are stamped "Completed" and returned to their maker to show the order is completed. All drawings bear the D. S. N. number in the reference space so that their origin can be traced quickly at any future time.

The advantages of this system are: That one form cares for all types of orders issued to the drafting department; they are practically self-functioning; they serve as a requisition, routing sheet, follow-up and permanent record; they show at all times what is to be accomplished and what has been accomplished; they account for all time expended by the draftsmen as all time used is recorded on the back of the form, and they create a flexible flow of production in the department. When an estimate is requested on a new job, a similar plan may be found in the completed orders and a dependable time element obtained.

—M. W. Elmendorf,
Rochester, N. Y.

MEN OF MACHINES

Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design

EXECUTIVE control of Diesel Engine Manufacturers' association now rests with H. Birchard Taylor by virtue of his election to the post of president. The task falls into the hands of a capable man who will devote a considerable portion of his time in actively promoting the high standards of the organization.

Professionally, Mr. Taylor now is consulting engineer to Baldwin Locomotive Works in Philadelphia, the city of his birth on Nov. 17, 1882. After graduation from the University of Pennsylvania in 1905 he became a draftsman in the hydraulic department of the I. P. Morris Co. In 1911 he was made hydraulic engineer. He was appointed assistant to the president of Wm. Cramp & Sons Shipbuilding & Engine Building Co. in 1915, becoming vice president in 1917. Holding this office until 1927, he then was elected president of Cramp-Morris Industrials Inc.

Mr. Taylor holds a number of patents covering various types of hydraulic turbines and pumps. He is a contributor to the technical press and is a past vice president councilor of the American Society of Mechanical Engineers.

PARTICULARLY interesting to the engineering profession is the recent announcement of the appointment of Herman H. Lind as manager of the National Machine Tool Builders association, filling the vacancy caused by the resignation several months ago of Boyd Fisher. Executive training gained through long experience in supervisory capacities qualifies Mr. Lind admirably for his new post.

It was in February, 1884, that Mr. Lind was born in Canton, O. There he attended McKinley high school and after graduation entered the employ of the Columbus Buggy Co., at Columbus, O. At the end of two years he resigned to take a position with the Ohio Body and Blower Co., Cleveland, where he remained for 17 years. During this long association he became intimately acquainted with sales, engineering, manufacturing and accounting problems and rose to the position of vice president and general manager of the organization.

For the past ten years, except for the period during which he was general manager of the Malleable Iron Research institute, he has been a business consultant and negotiator for industries. His successful dispatch of the duties in connection with the research organization augur well for a brilliant future in the undertaking of his new managerial responsibilities.

TWO new experimental aircraft designs brought out by Great Lakes Aircraft Corp., Cleveland, were developed under the personal supervision of P. B. Rogers who recently was appointed vice president in charge of engineering and a director of the company.

Mr. Roger's initial work in aircraft design dates back to June, 1920, when he entered the employ of the Glen L. Martin Co., with which organization he was affiliated until it left Cleveland for Baltimore. A Chicago-born man (July 1, 1896) he attended Ohio State university where he studied mechanical engineering. At the inception of the Great Lakes corporation in 1929 he was appointed assistant chief engineer and later chief engineer.

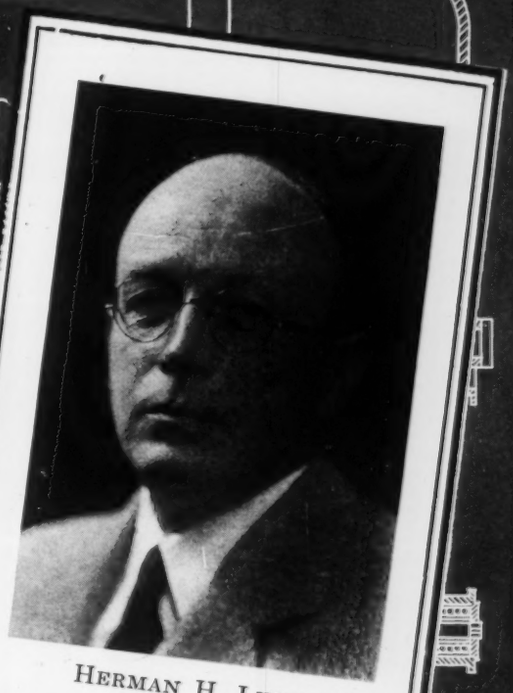
During the World war Mr. Rogers served as second lieutenant in the artillery division of the army. His present capacity as engineering vice president places him in complete charge of design and development of military and commercial airplanes, particularly of the former which the organization is building for the United States navy.

VICE president of the American Society of Mechanical Engineers was written behind the name of C. F. Hirshfeld in the recent report of the nominating committee of that organization. The new candidate is chief of the research department, Detroit Edison Co., Detroit. His early ambition was projected toward mining engineering but electrical engineering was his ultimate choice.

For his B. S. degree he studied at the University of California, graduating in 1902. In the fall of that year he entered Silby college, Cornell university, as a graduate student in mechanical engineering. 1903 found him employed as an instructor in experimental engineering there. Dr. Hirshfeld advanced to assistant pro-

Leaders in Design, Engineering and Research

H. Birchard Taylor



Herman H. Lind

P. B. Rogers

C. F. Hirshfeld

fessor and then to professor of mechanical engineering.

A master of mechanical engineering degree was conferred upon him in 1905 at Cornell where he remained as a member of the faculty until 1913. During this period he was author and co-author of several text books. Simultaneously he carried on a private consulting practice. At the termination of his professorship he became associated with the Detroit Edison Co. Dr. Hirshfeld has been prominent in technical society activities, and during the World war he was granted a leave of absence to serve in the ordnance department of the army in which he received the commission of lieutenant colonel. In June of this year he was the recipient of an honorary degree of doctor of engineering from Rensselaer Polytechnic institute.

* * *

Calvin W. Rice, secretary of the American Society of Mechanical Engineers, has been appointed a member of the National Research council, division of engineering and industrial research, for three years.

* * *

Russel E. Lawrence has established and is president of Lawrence Institute of Technology, Highland Park, Mich. He recently resigned as dean of engineering, University of Detroit.

* * *

C. J. Freund, formerly apprentice supervisor, Falk Corp., Milwaukee, has accepted an appointment as dean of engineering, University of Detroit.

* * *

Frank H. Crockard, retiring president of the Woodward Iron Co., will retain his connection with the company in the capacity of consulting engineer, with offices in Birmingham, Ala.

* * *

Clifford E. Roberts, who recently held the position of design engineer on military airplanes with Consolidated Aircraft Corp., Buffalo, has returned to the Glenn L. Martin Co., Middle River, Baltimore, Md., to assume charge of the design group of that organization.

* * *

Dr. Earle R. Hedrick, professor of mathematics and chairman of the department of mathematics at the University of California, Los Angeles, has been appointed chairman of a committee on the teaching of this subject in the colleges and universities of the North Central association.

* * *

Prof. Arthur N. Talbot recently was awarded the Lamme medal at the fortieth annual meeting of the Society for the Promotion of Engineering Education held recently at Corvallis, Oreg. The medal is given to "a chosen technical teacher for accomplishment in technical teaching or actual advancement of the art of technical training."

* * *

J. C. Whetzel, connected with the American Sheet & Tin Plate Co. as manager of the research laboratory since 1922, now is assistant to the vice president.

* * *

W S.. Paine, manager of the engineering and inspection department of the Aetna Life Insurance Co., Hartford, Conn., has been elected president of the Engineers' Club of Hartford.

* * *

Harry A. Curtis, director of research, Vacuum Oil Co., New York, has been appointed by the council of the American Institute of Chemical Engineers as chairman of the committee on chemical engineering education.

* * *

William R. Huey, now located at Swarthmore, Pa., is engaged in consulting work on corrosion and materials of construction. He formerly was associated with the duPont company for 10 years during which he became its metallurgical and corrosion engineer.

* * *

E. S. Taylorson, appointed assistant director of research in 1922 and engineer of tests in 1924, has been made manager of the research laboratory of American Sheet & Tin Plate Co.

* * *

W. D'Arcy Ryan, formerly director of the illuminating engineering laboratory of General Electric Co., has been named consulting engineer of the commercial lighting section of the company.

* * *

Harry Hall now is affiliated with McIntosh & Seymour Co., Auburn, N. Y., as a designer. He formerly was employed in a similar capacity with Fairbanks-Morse & Co., Beloit, Wis.

* * *

Walter C. Keys, consulting engineer, recently was elected to the council of the Society of Automotive Engineers to complete the unexpired term of the late Fred S. Duesenberg.

* * *

Louis Illmer has entered private practice as a patent attorney and research engineer at Cortland, N. Y. He formerly was in charge of the patent department of Brewer & Titchener Corp.

* * *

Louis E. Underwood, managing engineer of the stationary motor engineering department of the General Electric Co. at Lynn, Mass., is the

new manager of the Pittsfield (Mass.) works, succeeding E. A. Wagner, retired.

* * *

W. B. Joiner recently was appointed assistant sales manager of Larkin Refrigerator Corp., Atlanta. He formerly was in the engineering department of the company.

* * *

Harry A. Sutton now is research engineer and test pilot for Curtiss Aeroplane & Motor Co., Buffalo. Until recently he was vice president and chief engineer of American Airways.

* * *

L. L. Lindemuth, formerly associated with the Mesta Machine Co., Perin & Marshall, and the Colorado Fuel & Iron Co., has been appointed chief engineer of William B. Pollock Co., Youngstown, O.

* * *

D. W. McLenegan has been appointed assistant engineer of the commercial engineering division of the General Electric air conditioning department. He is a native of Milwaukee and a graduate of the University of Wisconsin in mechanical engineering with the class of 1921.

* * *

M. W. Reed succeeded B. H. Lawrence as chief engineer of the American Steel & Wire Co. at Cleveland, Sept. 1. Mr. Reed has been with the company for 16 years. Mr. Lawrence becomes assistant to John Hulst, vice president of the United States Steel Corp., New York.

* * *

W. C. Goodwin recently was appointed division engineer, air conditioning equipment division, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. After his graduation from Penn state in 1915 he enrolled in the Westinghouse graduate student course, attending the engineering and design schools.

* * *

William S. Culver, district engineer with headquarters at Cleveland, concluded 47 years in the employ of the General Electric Co. and its predecessors when he retired from active duty at the end of September. C. W. Fick, assistant district engineer succeeds him. Mr. Culver started work in the fall of 1885 in the shops of the Brush Electric Co. He was appointed district engineer 25 years ago.

* * *

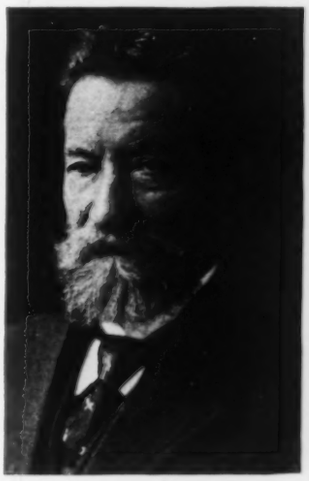
William LeRoy Emmet, consulting engineer, General Electric Co., and A. S. M. E. medalist, 1929, was the recipient recently of one of the John Scott awards presented annually by the Board of City Trusts, Philadelphia, for inventions or discoveries of industry which "may add to the comfort, welfare, and happiness of mankind." Mr. Emmet was named for his development of the mercury boiler. The award consists of a bronze medal, a certificate and $1000.

* * *

R. B. Vogt, for many years chief engineer of the Alvey-Ferguson Co., Cincinnati, is vice president and chief engineer of the newly organized E. W. Buschman Co. Inc., Cincinnati.

Obituaries

HUGO BILGRAM, designer and pioneer manufacturer of gear cutting machinery, died Aug. 27 at the age of 85 at his home in Moylan, Pa. Born Jan. 13, 1847, in Bavaria where he received his technical education, Mr. Bilgram at the age of 22 emigrated to this country. At Philadelphia he founded the Bilgram Gear & Machine Works Inc., of which he was president at the time of his death.



The first bevel gear generating machine was designed and built by Mr. Bilgram. That was in 1883. Prior to this, however, in 1875 while employed in the Southwark foundry as a machine designer, he found that by a modification of the Zeuner slide valve diagram the solution of some of his problems was facilitated and he therefore elaborated its application to reversible and variable expansion gears.

A chainless bicycle was among his earlier developments. He also devoted his engineering ability to designing cigarette machinery. Besides his technical pursuits he was the author of several treatises on economic subjects, among which was "The Remedy for Overproduction and Unemployment," written in 1928.

* * *

Magnus Washington Alexander, prominent engineer and authority on economics, died at his home in New York, Sept. 10, at the age of 62. For the past 16 years he had been president of the National Industrial Conference board. Mr. Alexander studied engineering abroad after which he became a designer for the Weston Electrical Instrument Co. in 1893. The following year he joined Westinghouse and in 1900 entered the employ of General Electric, remaining with that organization for 18 years in charge of design.

TOPICS OF THE MONTH

A Digest of Recent Happenings of Direct Interest to the Design Profession

INTEREST in diesel engines never lags and each time a new development comes to the fore engineers are quick to analyze its possibilities. One of the present topics of this nature centers around the new diesel engine idea for which Capt. Frederick A. Pippig, German aviation pioneer and now New York consulting engineer, has filed patent claims in the United States.

The development dates back to experiments conducted on fuels by Capt. Pippig six years ago. It involves the application of ultra-short waves in breaking down the surface tension of fuel molecules through ionization of the fuel air mixture and is claimed to attain the long-sought complete combustion at relatively low compression pressure.

A compression pressure of about 600 pounds per square inch is required to ignite the mixture in the cylinders of an ordinary diesel engine. Consequently light weight must be sacrificed for the necessary increase in strength of structural parts to withstand the high pressure. Under the new Pippig principle, it is asserted that semi-diesels may be built for high speed, with structural parts no heavier than those employed in normal gasoline-fueled internal combustion engines.

* * *

Develops Electrical Equipment Standards

DETAILED provisions covering approved methods for the installation and operation of electrical equipment in and around metal mines are included by American Standards association in the recently approved American Recommended Practice, Safety Rules for Installing and Using Electrical Equipment in Metal Mines. Among the topics covered are: General supervisory requirements; stationary electrical equipment in buildings, enclosures and underground; portable electrical equipment; circuits and conductors for both stationary and portable equipment; and a section defining the terms used in the text of the standard.

* * *

Large Molybdenum Deposits Discovered

FOLLOWING the discovery of large deposits of molybdenum concentrates at Mammoth, Ariz., a contract has been made whereby Molybdenum Corp. of America agrees to take the full output of ore from the mine there for a period of ten years.

This contract materially increases the reserves of Molybdenum Corp., which has been supplying its reduction plant at Washington, Pa., with concentrates from its own mine at Questa, N. M., since the corporation was organized more than ten years ago. Large untouched reserves still exist at Questa. Practically all the molybdenum in the world is found within the United States.

* * *

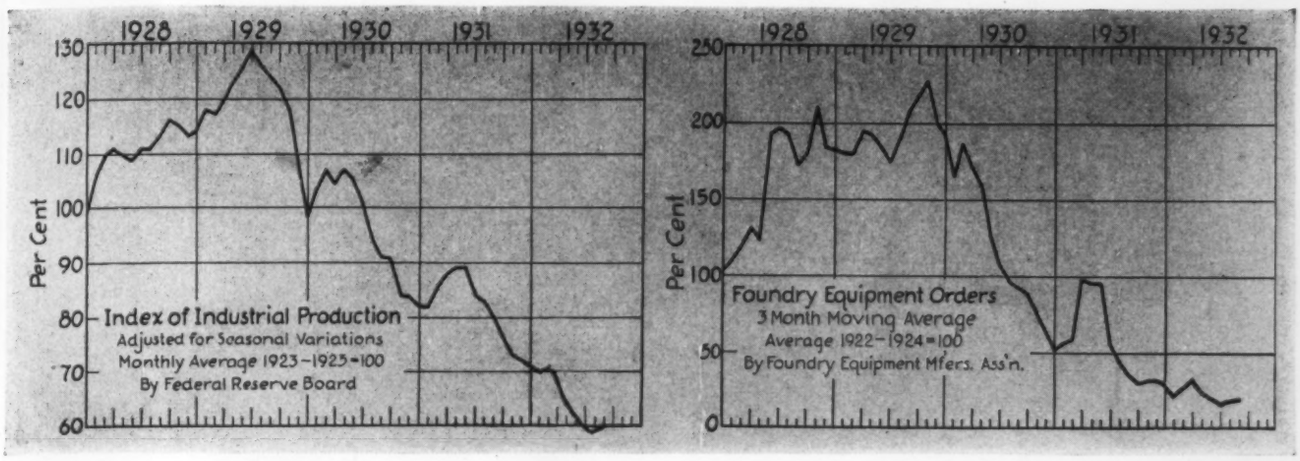
Diesel-Electric Car Sets New Record

TRAVELING the 268½ miles between London and Newcastle-on-Tyne, England, in 5 hours 38 minutes running time, the experimental diesel-electric rail car LADY HAMILTON achieved a record which compares favorably with the 5-hour booked time of the non-stop FLYING SCOTSMAN, the famous steam express. The time of the rail car was made despite a number of checks and signal stops necessary to allow the regular traffic to pass. Consistent high speed was maintained during the run, and the fuel consumption was 51 gallons, which gives a figure of 5.2 miles per gallon and a total fuel cost of $2.90 for the entire journey.

* * *

To Revise System of Tolerances

THE policy of the sub-committee of the sectional committee on allowances and tolerances for cylindrical parts and limit gages of the American Standards association will be to bring into line with present day practices the system of fits and tolerances tentatively approved in 1925. In its statement of policy the committee recognizes that experience has taught the futility of recommending a system that cannot be reasonably adhered to either economically or mechanically. The committee agreed that the recommendations when eventually submitted shall be characterized by the extreme simplicity of their presentation. It further recognizes that the recommendations which it will bring forth should be put into operation by practical men. While theoretical considerations cannot be ignored, they must not become a part of the recommendation if they interfere with the practicability of the scheme proposed.

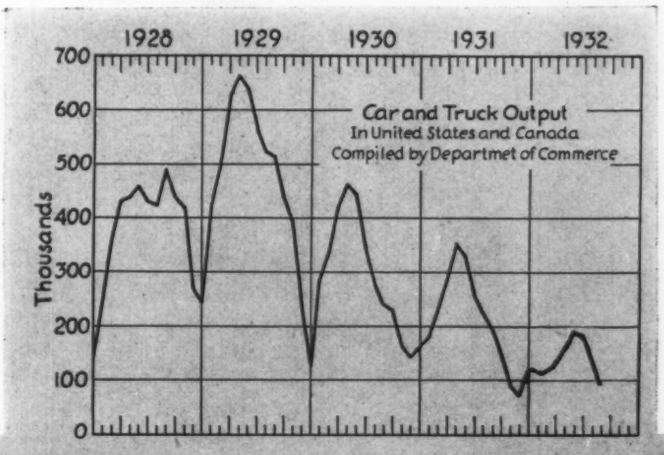


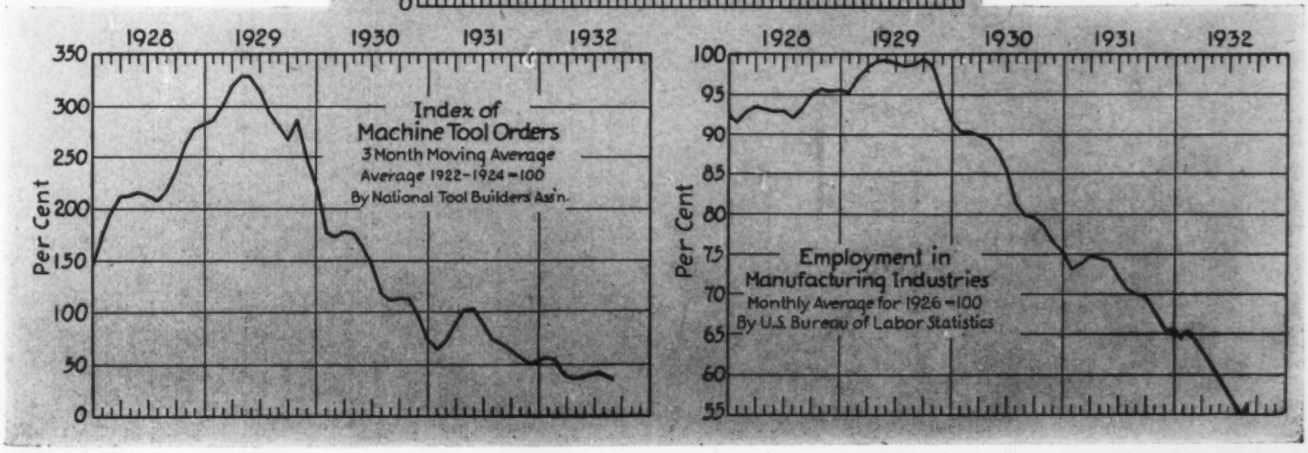
How Is Business?

GAINS greater than seasonal made in car loadings, steel operations, commodity prices and employment give evidence that the buoyant optimism of the last two months has its basis on the definite assurance of increasing business. These indexes, although still far below the comparable period of last year, show far greater and more sustained advances than at any time this year.

The most encouraging signs of improvement are to be found in the figures on industrial production and employment. Definite advances by these two presage increased buying power for thousands of families and such an increase will bring about better business generally. Statistics from sixteen major industries for August show a 0.5 per cent increase in employment as compared with July, reversing a two year continuous downward trend.

Revival of activity in consumer goods industries creates better feeling toward the outlook for heavier industries. With revenue freight loadings rising to the highest point for the year it would seem that the heavier industries are already benefiting from the effects of the sustained optimism. One such industry which has long been experiencing the poorest business in its history is the foundry group, and here again improvement has been registered. In August, gray iron founders reported a quite satisfactory increase in production, new business and unfilled orders besides noting additional business in prospect.





NOTEWORTHY PATENTS

A Monthly Digest of Recently Patented Machines, Parts and Materials Pertaining to Design

TO FORM a web or sheet from plastic material so that it will be of uniform thickness and free from minute waves Frederic A. Parkhurst has designed and patented an extruding machine incorporating a unique idea. The unit, identified by patent No. 1,844,972 assigned to Fiberloid Corp., Indian Orchard, Mass., is shown in Figs. 1 and 2. Power is supplied to rotate roll 30 in the direction of the arrow, Fig. 1, and plastic material such as celluloid is forced under pressure through nozzle 12 of the extrusion press 11 into orifice 23 to form web *W*.

Rotation of roll 30 assists in moving the web of plastic material through orifice 23 and at the same time exerts an ironing action upon the web, tending to smooth and polish its surface. Web *W* is discharged from the orifice over the rounded surface 19 through opening 20 and upon guide roll 50, whence it passes to the drying and curing apparatus. The web is maintained in a suitable plastic condition during its passage through the orifice by circulation of water at proper temperature through passages 16 in casing 10 and within the interior of hollow roll 30.

Position of roll 30 within the bore 15 may be

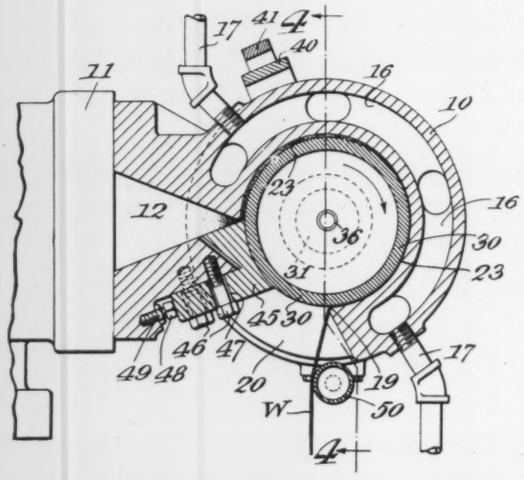


Fig. 1—Rotation of roll as plastic material is forced out by pressure forms a smooth sheet of uniform thickness

adjusted so that the orifice 23 gradually decreases in depth from its end communicating with nozzle 12 towards the opposite end opening 20. This is accomplished by releasing bolts 22 and 28 and turning the eccentric flange 21 and

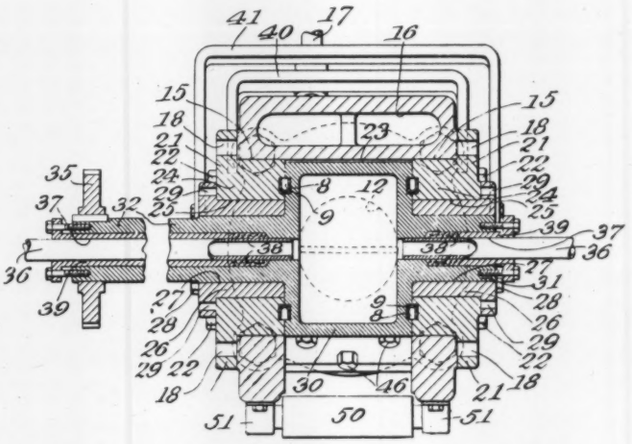


Fig. 2—Position of the roll 30 may be adjusted by bails to change the thickness of the web of plastic material

eccentric bushings 26 by means of bails 40 and 41 respectively, Fig. 2. Final thickness of the web produced is of course, determined by the depth of the orifice 23 at its discharge end. When it is desired to change the thickness of the web by adjusting the position of roll 30, the position of member 45 is changed to bring its curved end, which corresponds to the curvature of the roll, adjacent the surface of the roll. Rotation of the roll causes the plastic material to move into orifice 23 rather than past member 45.

MOUNTING of the cylinders of a pressure-operated mechanism for simultaneously adjusting the inlet guide vanes of hydraulic turbines has been improved by Joseph J. Ring for the Allis-Chalmers Mfg. Co., Milwaukee. His patent covering developments in turbine gate mechanism to eliminate the use of a pit ring for supporting the cylinders, recently was granted by the United States patent office and assigned No. 1,873,980.

Plan view, Fig. 3, illustrates the invention as applied to the conventional setting of turbine with the shifting ring 6 inside the guide vane circle. In this structure a speed ring 2 surrounds and supports a cover plate 18 provided with a bearing 7 for a common shifting ring 6 for simultaneously adjusting an annular series of pivotally supported guide vanes 1.

In the new design the cylinders 10 which operate in opposite directions in rotating the ring 6, are supported by bracket arms 12 connected

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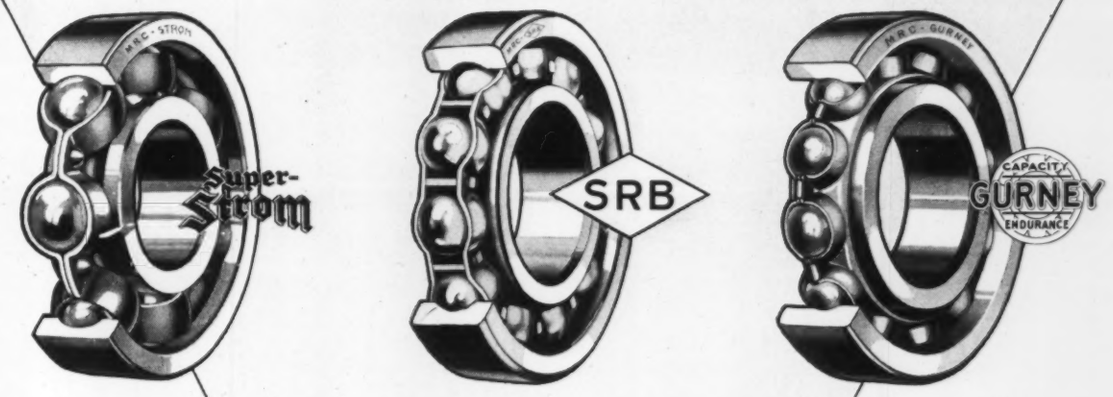

BALL BEARINGS

M-R-C Strom SRB GURNEY BALL BEARINGS

BY consolidating the Gurney, SRB and Strom lines under one sales organization, the Marlin-Rockwell Corporation now offers to its customers the following complete ball bearing service: Products of proven quality from these three well known makers of ball bearings; Engineering service based upon many years of experience in applying ball bearings to all types of applications; Comprehensive lines embracing twenty-one types and all standard sizes of ball bearings with many extra large bearings and special designs.

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with the free end of each cylinder. These arms are of equal length and are pivoted at their outer ends on a common pivot pin 14 carried at one end of a link member 13. With the operating mechanism of this invention there is a

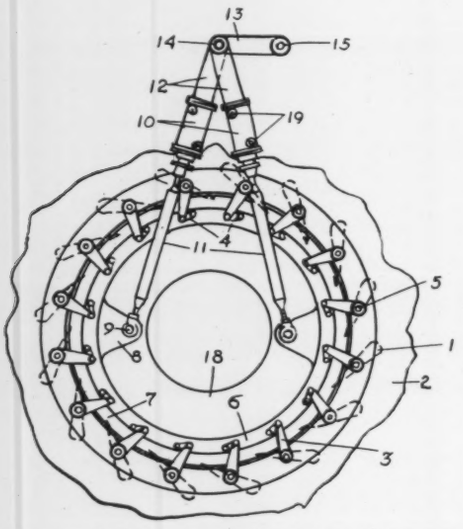


Fig. 3—Cylinder mounting of turbine gate mechanism eliminates use of pit ring

small resultant side or lateral thrust produced by the action of rods 11 against bearing 7, supporting shifting ring 6. This thrust, if the forces acting on the rods 11 are equal, will be the only effective force operating on pin 14 which joins arms 12, and will act in the direction of the link member 13 as positioned in Fig. 3.

It will be apparent that the value of the thrust will depend upon the angle included between the rods and since a relatively small acute angle is contemplated the thrust always will be much less than the equal forces in rod 11. Therefore only a limited force is necessary to be carried by the foundation member which supports shaft 15, and the usual heavy and expensive pit ring may be eliminated if other conditions warrant.

A SHOCK absorbing mechanism embodying interesting design details has been patented by Stacy B. Haseltine and assigned to W. H. Miner Inc., Chicago. The unit is especially adapted for railway draft riggings of rugged construction and high capacity. Shown in Fig. 4 is a longitudinal view of a portion of railway draft rigging in which the improvements covered by the invention are incorporated.

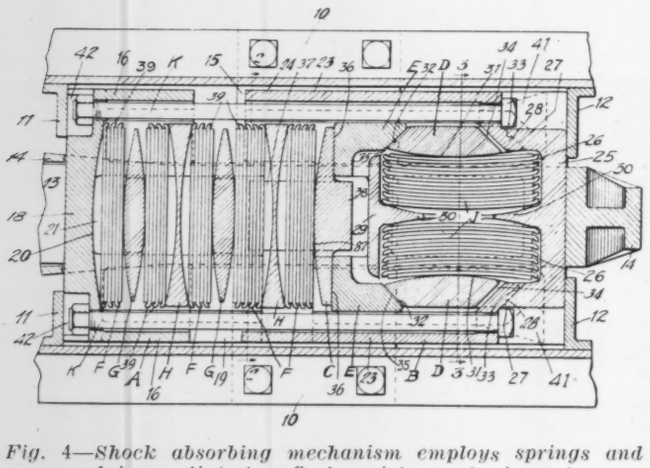


Fig. 4—Shock absorbing mechanism employs springs and wedging action to effect resistance to impacts

In operation of the device during a draft or buffing action the follower casings *A* and *B* will be moved toward each other, thereby flexing the laminated plate spring units *F* between the bearing faces on the follower casing *A*, the spacing members *G* and *H*, and spring follower *C*. The actuating force will be transmitted through the spring follower to the wedge blocks *E* and a wedging action with consequent friction will be set up between the latter and the side members *D*, they being wedged inwardly by the faces on the wedge blocks *E* and casing *B*.

As the side members *D* are forced laterally inwardly toward each other the laminated plate spring members *J* will be flexed between the convex bearing surfaces of the members *D* and the concave bearing surfaces of wall sections 30.

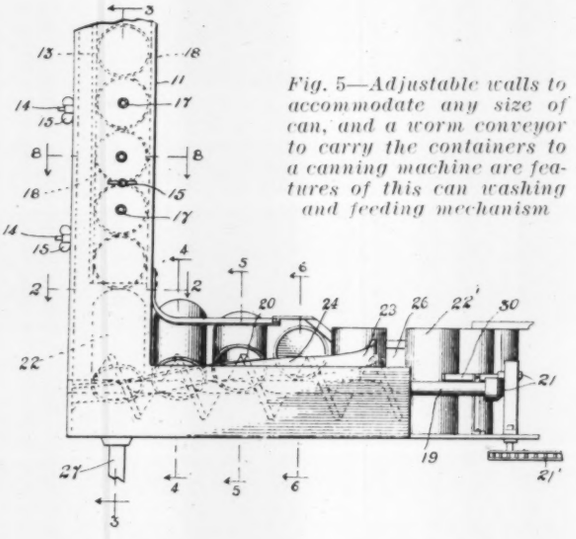
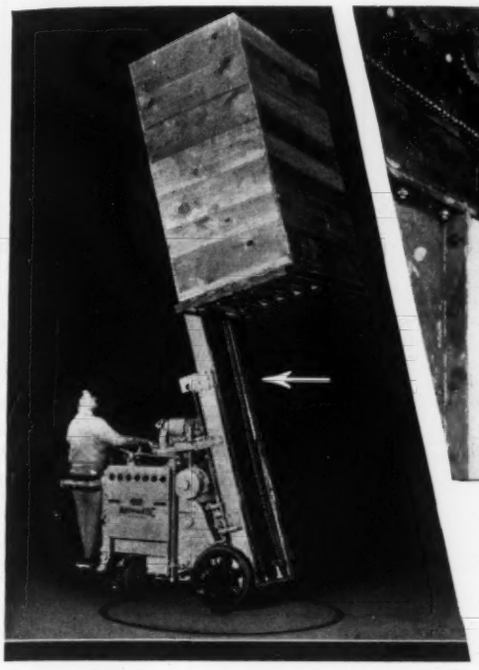
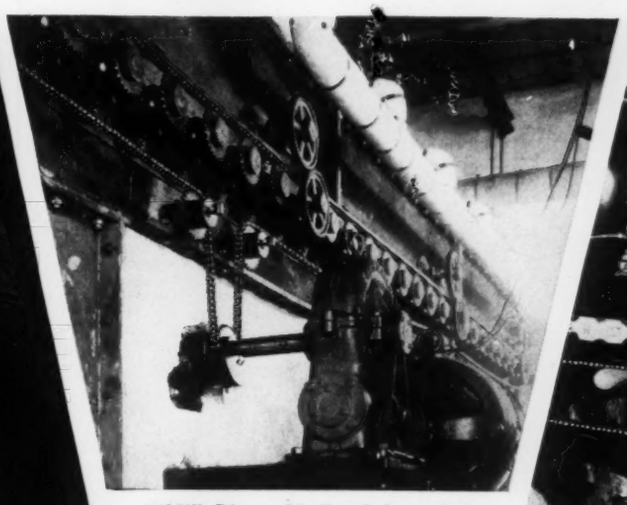


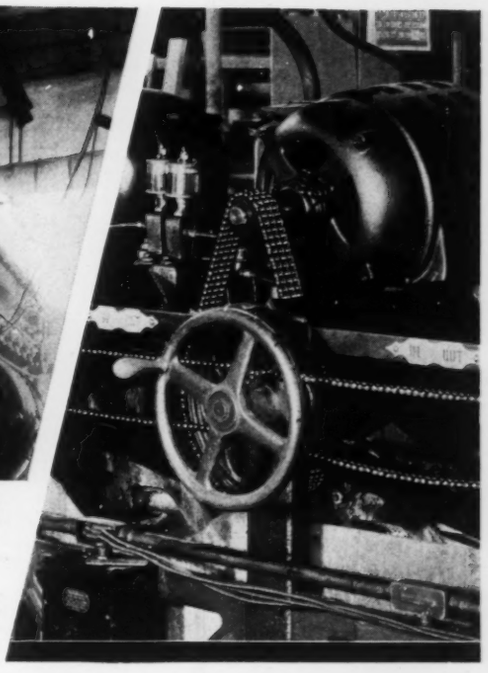
Fig. 5—Adjustable walls to accommodate any size of can, and a worm conveyor to carry the containers to a canning machine are features of this can washing and feeding mechanism

Compression of the mechanism will continue either until the actuating force is reduced or the movement of the parts is limited by the ends of the housings engaging each other, the spring units *F* coming into full surface contact with the respective convex and concave faces of the spacers and followers, and the projection 38 of the follower *C* engaging web 29. When the actuating force is reduced, the tendency of the members of the laminated plate spring to assume normal position will return all of the parts to the full release position shown in Fig. 4. Outward movement of casings *A* and *B* with respect to each other is limited by retainer bolts *K*. The patent is designated No. 1,874,288.

ELIMINATION of handling by attendants is provided by a new mechanism for washing and feeding cans to a canning machine. The







ABOVE: Diamond Roller Chain on cloth-ageing machine built by New England Butt Co., Providence, R. I.

AT LEFT: Tiering and lift truck driven with Diamond Roller Chain.

AT RIGHT: This Diamond Drive outlasted three drives of another type under identical unfavorable conditions—7½ hp. motor at 1750 r. p. m.

"It Made the Machine Quiet and Smoother Running"

The maker of a well-known cloth-ageing machine found that the use of positive-ratio Diamond Roller Chain made the operation *smoother* and *more quiet.* All the rolls are turned, (some in one direction and some in the other) at *exactly* the same speed and at the proper speed-ratio.

A manufacturer of tiering and lift trucks applied Diamond Chain successfully for an operation impossible by any other method.

●

A Diesel engine builder reports that his timing with Diamond Chain was more consistently and dependably accurate than ever attained before.

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A rug cleaning machine manufacturer increased the value of his machine $50 by replacing malleable chain with Diamond Roller Chain.

●

Hundreds of these citations could be made here all attesting to the unusual degree of perfection of Diamond Roller Chain.

With Diamond Roller Chain Drives, the positive action of spur gearing is provided with the great advantage of the load being distributed among a large number of teeth instead of being concentrated upon one engaging tooth per gear.

Wear and stress are reduced, and since the idle strand of roller chain runs slack, bearing friction is minimized.

Power is saved because there is no slippage or friction losses. With the maintained velocity and dependability that Diamond Roller Chain insure, efficient production by the driven machine is *maintained uniformly.*

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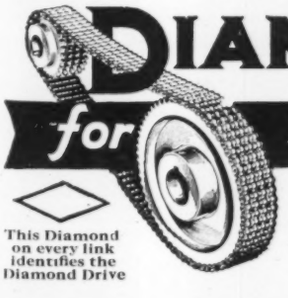

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DIAMOND CHAIN & MFG. CO.
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Gentlemen: Please send me a copy of Booklet 104-A, "Simplifying and Improving Machine Design."

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A-6594

design of this device was conceived by Charles H. Ayars who has patented it for the Ayars Machine Co., Salem, N. J. Another feature of the washing and feeding mechanism is the means for accommodating different sizes of cans. To provide this the designer has incorporated adjustable walls for different diameters and lengths, adjustment being effected through screws 14 and winged nuts 15, Fig. 5.

A side elevation showing the position of the cans at different stages of their progress in the mechanism is depicted in Fig. 5. In operation the cans are introduced into housing 11 with the open ends against the front adjustable wall, so that in passing down within this housing, the open ends successively will pass watering nozzles 17. Under pressure the water, hot or cold, will be directed into the cans.

As the worm conveyor made up of core 19 and fin 20, Fig. 6, rotates, the lowermost can is engaged by fin 20 and is withdrawn from the housing, being maintained in an inclined position in transit long enough for the water to drain out. The angle of inclination may be varied at will. By the action of the worm and guide strips 23, 24 and 25, the can gradually is righted from an inclined to a horizontal position, and subsequently righted suddenly to an upright position by the action of the worm and guide finger 28.

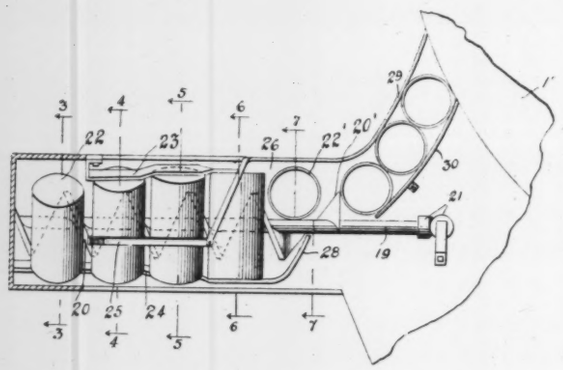


Fig. 6—The worm conveyor is designed to change cans from a horizontal to an upright position

The upright can at this point is in position to be "kicked" by fin section 20', Fig. 6, which will force the can along with the preceding ones in the runway, toward and into the machinery. By having this apparatus operating in step with the intermediate machine the can is delivered at the proper interval. Patent number is 1,850,067.

Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

VIBRATION INSULATOR—1,876,704. The device consists of a sheet metal casing for a damping element, comprising a cap formed with tongues, and a base plate adapted to be secured to a support, the plate being formed with slots to receive the tongues and with a marginal bearing rim adapted to space the body of the plate from the support. The plate also is provided with a central lug bearing against the support. Assigned to Rubber Shock Insulator Corp., Bridgeport, Conn.

COUPLING—1,879,364. A coupling receiving member having a body, radial openings in the body, balls in the openings, a ball actuating ring on the body and a resilient ball retaining ring within the device. Granted to Louis L. Lomar, Houston, Tex.

LITHIUM ALLOYS AND PROCESS OF PRODUCING THE SAME—1,869,493. Claim two sets forth that in this process the anode is placed in the lower portion of the fused bath and the cathode is placed in the upper portion of the bath. Granted to Hans Osborg, Frankfort-on-the-Main, Germany.

METHOD OF PRODUCING SHEETED COMPOUNDS—1,869,491. This patent covers the method of producing sheeted compounds, consisting in reducing dry waste fiber to a finely divided condition, thoroughly impregnating the divided fiber with an uncured resin, reducing the mass to a flowable condition, forming a uniform film of the mass, and drying into a coherent sheet. Assigned to Joseph Gatti, New York.

DE-CLUTCHING MECHANISM—1,879,184. A clutch control comprising fluid operated means operatively connected with the clutch of an internal combustion engine driven automobile, a conduit connecting the mechanism with the engine, a reservoir and a valve connecting the reservoir and the conduit so that the mechanism may be brought into communication selectively with the reservoir and the engine. Granted to William Gilmore, Meridian, Miss.

BEARING ADAPTER—1,876,543. Covered by this patent is a bearing adapter comprising a head fitted into one end of a tubular roller, the head having means adapted to engage the end of the roller and also having an inwardly turned flange provided with an axial bore, and a member having a cup-shaped portion fitting in the bore and adapted to receive a bearing cage. Assigned to Mathews Conveyor Co., Ellwood City, Pa.

BOARD MACHINE—1,879,143. A cylinder board machine including the usual endless felt receiving the wet pulp from the cylinder mold and an endless wire over which the felt passes and a pair of transfer press rolls between which the felt, the pulp and the wire pass, the transfer rolls being so constructed and arranged that the pulp is transferred from the felt to the wire. Assigned to Downingtown Mfg. Co., Dowingtown, Pa.

BEARING—1,879,356. A bearing adapted to follow movements of a shaft so that the bearing is at all times coaxial with the shaft. The movement of the shaft results from the shaft bending between the bearings, comprising a bifurcated support, a bearing mounted in the support, extensions on the bearing having convexed surfaces resting upon the ends of the stems of the support and means for resiliently securing the bearing to the support. Assigned to A. B. See Elevator Co., Nutley, N. J.

VEGETABLE SLICING MACHINE—1,879,008. A cutting mechanism for fashioning vegetables into triangular shapes. It consists of a grid of blades intersecting one another at right angles to form a number of openings. A second grid of blades is superimposed upon the first grid with the blades of the upper grid crossing the blades of the lower grids at the point of intersection of the blades of the lower grid, to form between the grids triangular shaped openings. Means are provided to push the vegetables through these openings. Assigned to Joshiah Anstice & Co., Rochester, N. Y.

HUNDREDS of industrial men have returned to their plants, after a visit to General Electric factories, convinced that the answer to almost any fabrication problem is already in the arc-welding-engineering files of the General Electric Company — convinced that all the arc-welding equipment they might need can be obtained on one order blank from one dependable manufacturer.

That's why so many instinctively turn to the nearest G-E office for every arc-welding requirement.

530-127

GENERAL ELECTRIC

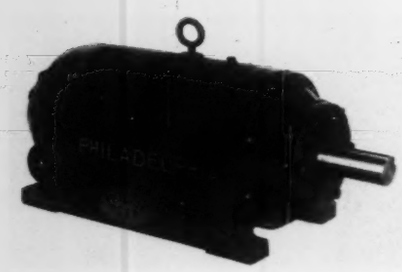
NEW MATERIALS AND PARTS

Worthy of Note by Those Engaged in the Design of Mechanisms or Machines

Reducer Has Efficient Base

MOTOR and gear apparatus in the horizontal MotoReduceR introduced by Philadelphia Gear Works Inc., Philadelphia, are self-contained in a single housing with supporting feet at each end of the frame, thus eliminating overhanging gear or motor. The design permits close coupling and does not require a flexible coupling and baseplate.

All gears are made from heat treated nickel steel, have helical teeth and are run in an oil bath. Bearings are of the antifriction type, the slow speed shaft being mounted on oversize roller bearings. The unit is available in single, double and triple types with ratios up to 450:1 and can be furnished with standard open type or totally enclosed fan cooled motors, polyphase and single phase. Units are also available with direct current motors up to 10 horsepower.



Horizontal type reduction unit has gear apparatus and motor assembled as one unit

Control System Is Simplified

A SIMPLIFIED system of control for electromagnetic clutches and brakes applied to punch and forming presses has been developed by Cutler-Hammer Inc., Milwaukee. The control incorporates patented safety features which it is claimed insure the safety of the operators, and give the flexibility that should help the maximum output. This feature is a plurality of palm operated push buttons, mounted directly on the slide of the press. Each hand of each operator is occupied in holding a button depressed and consequently is free from the press when the slide descends to the bottom of the stroke.

Flexibility of control is obtained by providing three additional methods of operation with simple means of transfer to any one of four methods desired. Transfer is made on snap switch type transfer switches.

Bearing Takes Combined Loads

DEVELOPED to provide a bearing adapted not alone for radial loads but also for high thrust loads in either direction, the new bearing introduced by Norma-Hoffman Bearings Corp., Stamford, Conn., has a width no greater than that of a standard single row ball bearing. The outer ring is made in two parts, and both inner and outer raceways are ground to a special curvature suitable for safely carrying heavy end thrust. A one-piece retainer of extruded bronze rides, or is carried, upon the ground flanges of the inner ring. The bearings are available in the light, medium and heavy metric series in a range from 10 to 100 m/m bore. They should be used only where the thrust load exceeds the radial load.

Bearing is adapted for both radial loads and for high thrust loads in either direction

Improved Belting Is Developed

TRANSMISSION belting of a new type which is applicable for those machines where endless belting or belting laced with conventional fasteners is impractical has been designed by B. F. Goodrich Co., Akron, O. The new belt, named Hiflex Junior, is built up of a greater number of plies of a specially woven fabric designed primarily to give the characteristics necessary when transmission belting is to be spliced endless right on the machine. The company

Why TWIN-DISC CLUTCH IS PREFERRED FOR THE well known MONARCH LATHE

Twin Disc Clutch
No. 6048-T6½

A recognized leader in its field, Monarch Lathe is noted for advanced design, precision workmanship, trouble-free long life. A majority of lathe improvements made in the past ten years were pioneered by Monarch engineers, and their choice of the Twin Disc Clutch was a logical forward step in its betterment. They give these significant reasons...

(1) "Because of the simplicity of design, smoothness of operation, duty capacity, infrequency of adjustment, ease of adjustment when necessary.

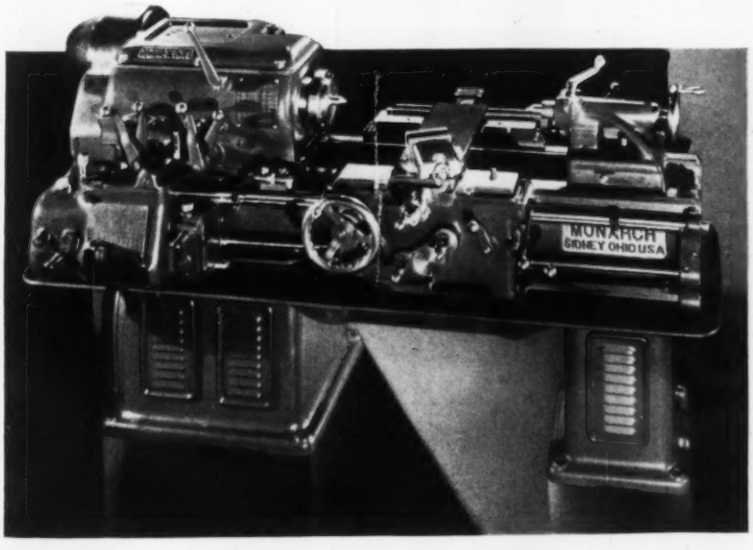
(2) "The frequent starting and stopping of any lathe demands a well-designed, well-made, smooth-operating clutch. The clutch is a vital unit of a lathe and determines largely its success.

(3) "Due to the simplicity of the Twin Disc Clutch, the number of parts in our lathe is held to the minimum without sacrificing in any respect the function of its parts. This also effected a reduction in the total cost."

Logically, *The Clutch Specialists* can build a better clutch at lower cost than a manufacturer in some other line can build it.

The clutch is only a small part of a lathe, but of great importance. It transmits and controls the power; keeps the lathe in motion, and lathe power must be under perfect control.

Thirteen years of close cooperation with leading machine tool makers in solving their clutch problems makes the advice of Twin Disc Clutch Engineers valuable to you. Specific recommendations and Engineering Data Book on request. Write to the *Twin Disc Clutch Company, 1325 Racine St., Racine, Wisconsin.*



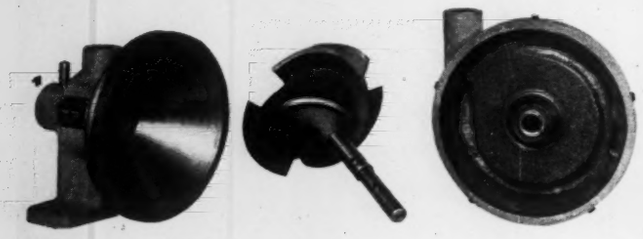
Monarch 16, Model C Tool Room Lathe..a product of the Monarch Machine Tool Co., Sidney, Ohio.

TWIN DISC CLUTCHES

also has developed a special cement and tie gum for making the splice. The belting is made only in widths of 6 inches and under.

New Pump Has Few Parts

NECESSITY for close fitting parts within the pump chamber has been eliminated and efficient operation maintained in the new Spiral-Flo pumps developed by Tomkins-Johnson Co., Jackson, Mich. The pump, shown herewith, is



Disassembled view of new pumps which will handle either water or oil and are not affected by foreign substances in the liquid

supplied with ½-inch intake and ¾-inch outlet to provide seven gallons per minute capacity at 1000 revolutions per minute and 14 gallons per minute capacity at 1725 R. P. M., or with one inch intake and one inch outlet, capable of 31 gallons per minute at 1725 R. P. M. The unit pumps either water or oil and is said to be not affected by grit, chips or foreign matter which may enter it. The shaft is mounted on ball bearings protected by standard oil seals. Since there is no appreciable back pressure, no relief valve is necessary. There are no gears which might wear out and cause trouble.

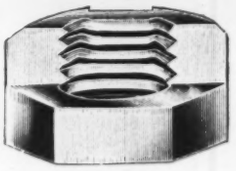
Develops Selenium Stainless Steel

THE first commercial use of selenium steel has been made in a free machining 18-8 stainless steel known as Carpenter stainless steel No. 8 by Carpenter Steel Co., Reading, Pa. This is an austenitic steel containing approximately 18 per cent chromium, 9 per cent nickel and 0.25 per cent selenium. When this brand of steel first was announced by the company a few months ago, it contained about 0.30 per cent sulphur as a free cutting agent. The sulphur now has been replaced by selenium with considerably improved results.

The greater transverse toughness of steel containing selenium reflects in several ways upon the fabrication and use of the product. The selenium steel is easier to roll and forge than the sulphur types—being less subject to splitting, cracking or opening at the ends. Selenium steel can be upset with greater safety and less trouble from splitting. From a corrosion resisting standpoint selenium also has some advantages. It does not impair in any way the resistance to the salt spray test and it does increase the resistance of the metal to certain chemical solvents such as boiling solutions of acetic acid or aluminum sulphate.

Wave in Thread Locks New Nut

OBTAINING a locking action by a wave in the upper thread section of the nut, a new lock nut placed on the market by Bayonne Bolt Corp., Bayonne, N. J., is said to hold in any position and not be loosened by vibration. The nut may be taken off one bolt and placed on another without lessening its efficiency. It is standard in all its elements and dimensions so that it fits any



Wave in upper thread section provides locking action

bolt thread and is made in all standard types and sizes from ¼ to 1½-inch diameter. It is available in any metal.

Introduces Improved Tracing Paper

MINERAL oil treated Vellum paper which will not transfer oil to other papers, can have erasures made on it with little difficulty and does not require the use of tracing cloth pounce has been introduced by the technical papers division of National Consumers Paper Corp., 227 Sixth avenue, New York. This paper, which is white and odorless, does not become brittle and has permanent transparency as no evaporation takes place. It is made of heavy rag stock transparentized to provide an economical paper for original drawings and tracing work.

Bearing Uses Bronze Retainer

BALL thrust bearings for clutch throw out or clutch release applications are a recent development of Bantam Ball Bearing Co., South Bend, Ind. This bearing, shown herewith, uses a cast bronze retainer for holding the balls instead of the conventional pressed steel retainer. A special grease retaining type band is used around the outside of the bearings, this band

WANTED:

THE MANUFACTURER of these strip steel megaphone rims wanted a perfectly flush joint strong enough to withstand cold die-pressing, and quick and inexpensive to produce.

A Linde representative suggested oxy-acetylene welding, with the type of jig shown above. The megaphone maker tried it—and got a joint that met every requirement.

How about your product? Is it light enough now, and strong enough? Easy enough to produce and finish? Profitable enough to make a cut in production costs needless?

If it isn't, oxwelding offers you one good way to get the results you want. But before you commit yourself to welding, get all the facts from The Linde Air Products Company, whose 25 years' experience in applying welding to every type of product may save you time and money.

Or even if welding doesn't seem to be the process you are after, get in touch with Linde anyhow. Oxwelding is being used for so many things that no one man can know them all. Maybe right now it is doing some job very similar to yours. Let Linde advise you frankly.

A card or a call to our nearest District Office will bring you complete information, without obligation. Mail the card or make the call *now,* and get the newest and best data on production welding.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

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extending down on one side past the center line of the balls so that centrifugal force instead of throwing the grease out tends to withhold the grease within the bearings.

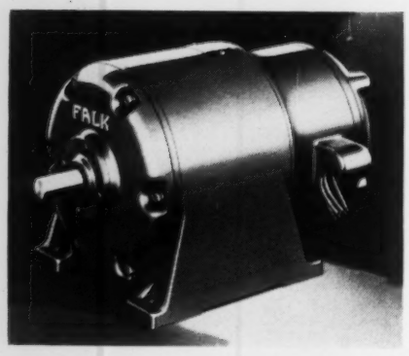
By use of the bronze retainer and the grease

Special design of retainer aids in keeping the grease within the bearing

retaining type band it is said to be possible to eliminate all of the oil tubes and grease fittings commonly used with bearings of this type. Although primarily an automotive bearing, this unit has wide possibilities for industrial equipment. The design of the band, however, would necessitate the machine being designed to accomodate this different type of band.

Reducers Have Integral Motors

ALL the advantages of separate motors and speed reducers and in addition increased compactness and simplicity are available in the three styles of Motoreducers designed by Falk Corp., Milwaukee. In these units, shown herewith, the gear housing acts as a support for the



Integral type of motorized speed reducer assembled complete with the motor

motor. In the integral type the motor bell is removed and the motor coupled through a bayonet type of joint to the gear case.

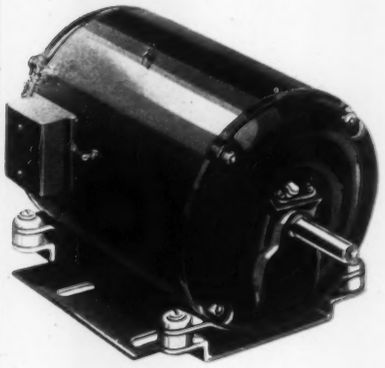
The round frame type of motor is used in the flexible model and the end bell retained. In the all-motor type any standard horizontal type motor may be used, the motor being connected through a flexible coupling to the reducer housing.

All three types are available in horsepowers from ¾ to 75, with ratios from 4.6 to 288. Nonplanetary helical type gears are used throughout. Bearings are oversize ball bearings in all but the larger sizes.

Capacitor Motors Are Compact

MOTORS which combine the advantages of the capacitor types with the neat appearance of other types now are being manufactured by Howell Electric Motors Co., Howell, Mich. These motors, shown herewith, have the capacitor mounted inside the motor frame so that the external lines are not disturbed by the capacitor box.

The equipment is manufactured in horsepowers from ⅛ to 1/3. Motors can be secured in either horizontal or vertical models, with waste-packed sleeve or double sealed ball bearing and with rigid or rubber mountings. They are manufactured with a large oil reservoir for the sleeve bearings with an abundance of wool yarn to hold sufficient oil to last for long periods without reoiling. If desired, stators and rotors for built-in equipment can be furnished by the company.



Motors have capacitor mounted inside the motor frame giving cleaner external lines

Bearings Are of Composition Material

BEARINGS made from synthetic resin with textile material as a base have been developed by Joseph T. Ryerson & Son Inc., Chicago. Resinoid completely fills and saturates the belting material used and the composite material is subjected to heat and pressure. At approximately one ton pressure per square inch and 340 de-

BEYOND THE TRADE-MARK..?

AFTER all, it isn't a trade-mark that drives your machinery—it isn't the trade-mark upon which you rely for unfailing power in your plant. It's the *motor*! The famous Fairbanks-Morse trade-mark is the symbol of quality which a pioneer manufacturer of motors puts on his motors. But in all fairness to yourself—do not regard it or any other trade-mark as anything more than a symbol. After you have investigated, weighed construction advantages and performance records, *then*, and then only can you buy according to trade-mark.

These are times of changing methods. The best value of yesterday may not be today's. Old buying habits and impressions of motor values may not be accurate *now*.

So we invite you to look beyond the trade-mark and submit a Fairbanks-Morse Motor to the most exacting investigation you can make. In the column at the right are shown a few of the new unusual methods which are employed to make Fairbanks-Morse Type Q Motors give longer trouble-free service. The *complete* story of this extra value will be sent on request.

FLEX-MOR DRIVE
Use Flex-Mor for troublesome short-center drives. Replace long-center drives and conserve space while reducing transmission losses. Flex-Mor is durable; the silent, elastic drive reduces bearing pressures and requires no dressing or lubricant; unaffected by dust, dirt, moisture or atmospheric conditions.

Fairbanks, Morse & Co.,
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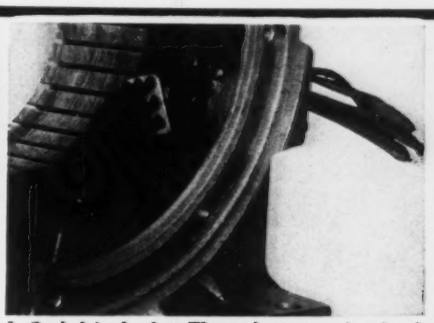
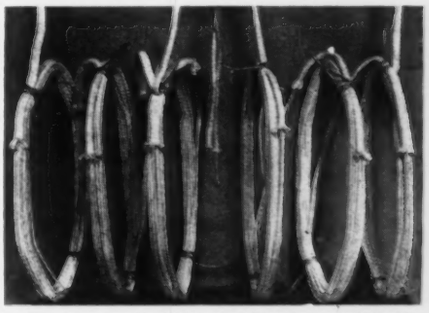
FAIRBANKS-MORSE MOTORS

32 branches at your service throughout the United States

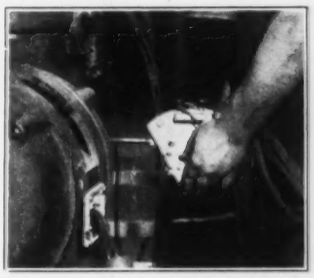


1. Sealed-in leads. Through an opening in the frame—and there anchored permanently with a special sealing compound. The roughest kind of handling during installation or afterward cannot put strain on the stator winding connections.

2. Special cuff insulation. Empire cloth inside of two special pre-formed fibrous sheets is inserted in the stator core slots. An ingenious method of folding makes a self-locking cuff and gives permanent protection from slippage and added protection to the windings.



3. Group wound coils. A phase group winding from one piece of wire—reduces end connections and eliminates a source of mechanical failure. Lead connections from these phase windings are *welded*, not soldered or brazed. An innovation in winding construction that keeps motors out of the repair shop.



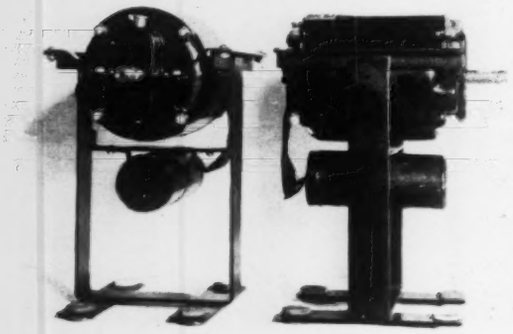
4. Every motor is given a thorough vibrometer test to make sure of proper running balance. Eliminate vibration and you reduce to a minimum the wear on bearings. Sealed-ball bearings and smooth running insure trouble-free service from F-M Motors under severest operating conditions.

5660-EA40.45

grees Fahr. the product sets. Physical characteristics are changed entirely and the bearing is no longer fusible or soluble. It cannot be resoftened by heat, will not absorb water or oil and is resistant to most acids. It is, however, attacked by hot caustic alkalies. The bearings are particularly satisfactory in cases where it is easier to apply water as a lubricant than oil, although they will operate satisfactorily with oil if this is desirable.

Motor Is Unusually Quiet

DEVELOPED for use with air conditioning units, the motor brought out by Ohio Electric Mfg. Co., Cleveland, is wound to run at 840 revolutions per minute and is provided with capacitor start and run to avoid the use of a start switch which might make a little noise at start or stop. The motor shown in the accompanying illustration is wound and operated at the one speed, but similar motors can be wound and controlled to operate at several speeds from 500 to 1750 R. P. M., although at speeds above 1000 R. P. M. the fan noise is almost certain to be objectionable.

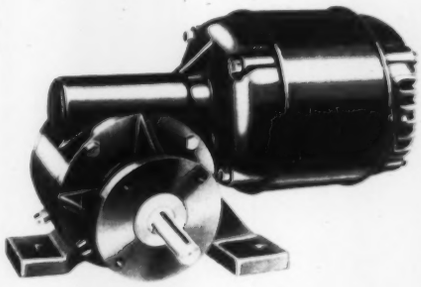


Capacitor start and run is used with motor to avoid unnecessary noise in air conditioning apparatus

Offers Motorized Reducer

STANDARD ball bearing motors built integral with worm gear reduction units in such a way that the end frame of the motor is a part of the gear housing and the worm is keyed to the motor shaft extension make up the new unit, type SW-2, in the line of motorized speed reducers built by Jannette Mfg. Co., Chicago. Twelve ratios ranging from 90:1 to 8:1 have been adopted as standard, although intermediate ratios and ratios up to 120:1 may be obtained. Motors of 1/6 to 1 horsepower are available. Standard motor speeds are 1725 and 1140 revolutions per minute.

The unit shown in the accompanying illustration is fitted with a foot and single flange mounting with the flange on the right hand side.

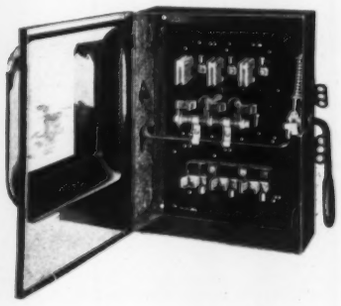


Motorized reduction units are available in twelve ratios ranging from 90:1 to 8:1

It also may have a flange on the left or on both sides, or it may be mounted with no flange. Flange-type units are furnished either with or without the mounting feet.

Improves Industrial Switches

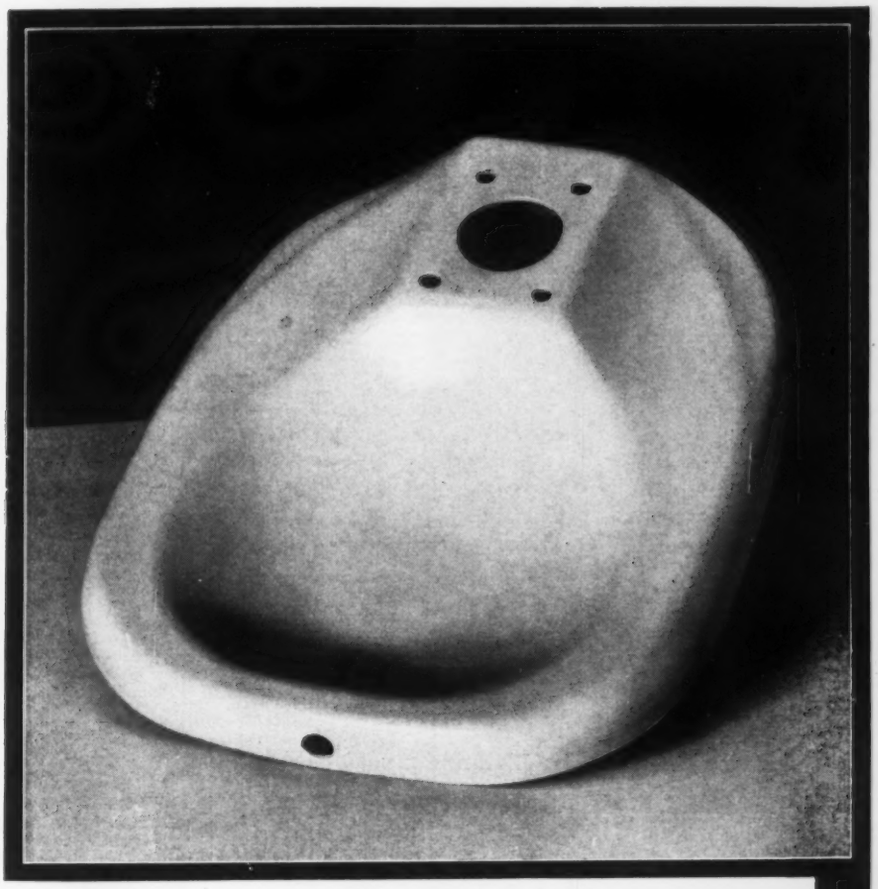
AN IMPROVED line of Type C industrial switches which have larger boxes, positive quick make and quick break operating mechanism and the addition of positive pressure fuse clips has been announced by Square D Co., Detroit. The same boxes, operating mechanism, copper and fuse clips used in the Type A line now are included in the Type C switches. Capacities range from 30 to 60 amperes, 250 volt, and 30 to 200 amperes, 575 volt, fused or unfused.



Industrial switches have positive quick make and quick break operating mechanism

Regulator Switch Announced

A NEW, compact pressure regulator switch with motor overload protection has been developed by Cutler-Hammer Inc., Milwaukee.



$3,631.46 Saved on One Part*

By substituting a G.P.&F. steel stamping for gray iron casting used as a base, a mixer manufacturer saves $3,631.46 annually on this one part alone.

The weight is reduced, breakage eliminated and the smoother surface of the pressed steel makes possible a better finish and appearance.

This is just another of the hundreds of cases that can be cited where many advantages result from the use of G.P.&F. Stampings.

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Then be sure the motor you use will give the maximum service. The success of your product—its ability to repeat with users—depends upon the motor, the heart of the appliance.
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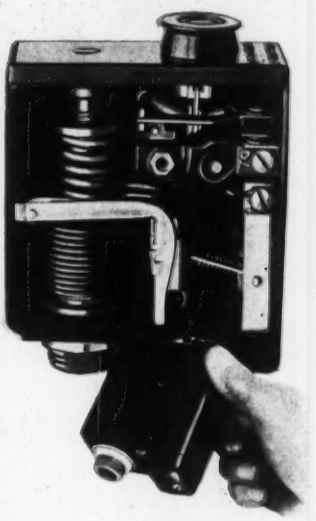
Menominee, Michigan
SIGNAL
MANUFACTURERS OF ELECTRICAL PRODUCTS

The switch, especially designed for water supply systems, is rated electrically for ¾-horsepower on alternating current, and ½ horsepower on direct current.

The device, shown herewith, can be adjusted to operate the system at a maximum pressure of 65 pounds, and provides a differential pressure

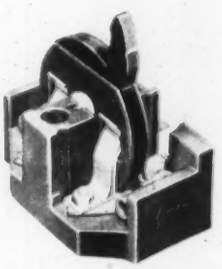


Pressure regulator switch can be adjusted to operate the system at a maximum pressure of 65 pounds

adjustment setting of from 12 to 28 pounds. The metal syphon operates through a toggle mechanism which prevents major pulsations of pressure being communicated to the contacts. A restricted orifice also prevents pump pulsations from reaching the switch mechanism.

Disk Switches Are Unusually Compact

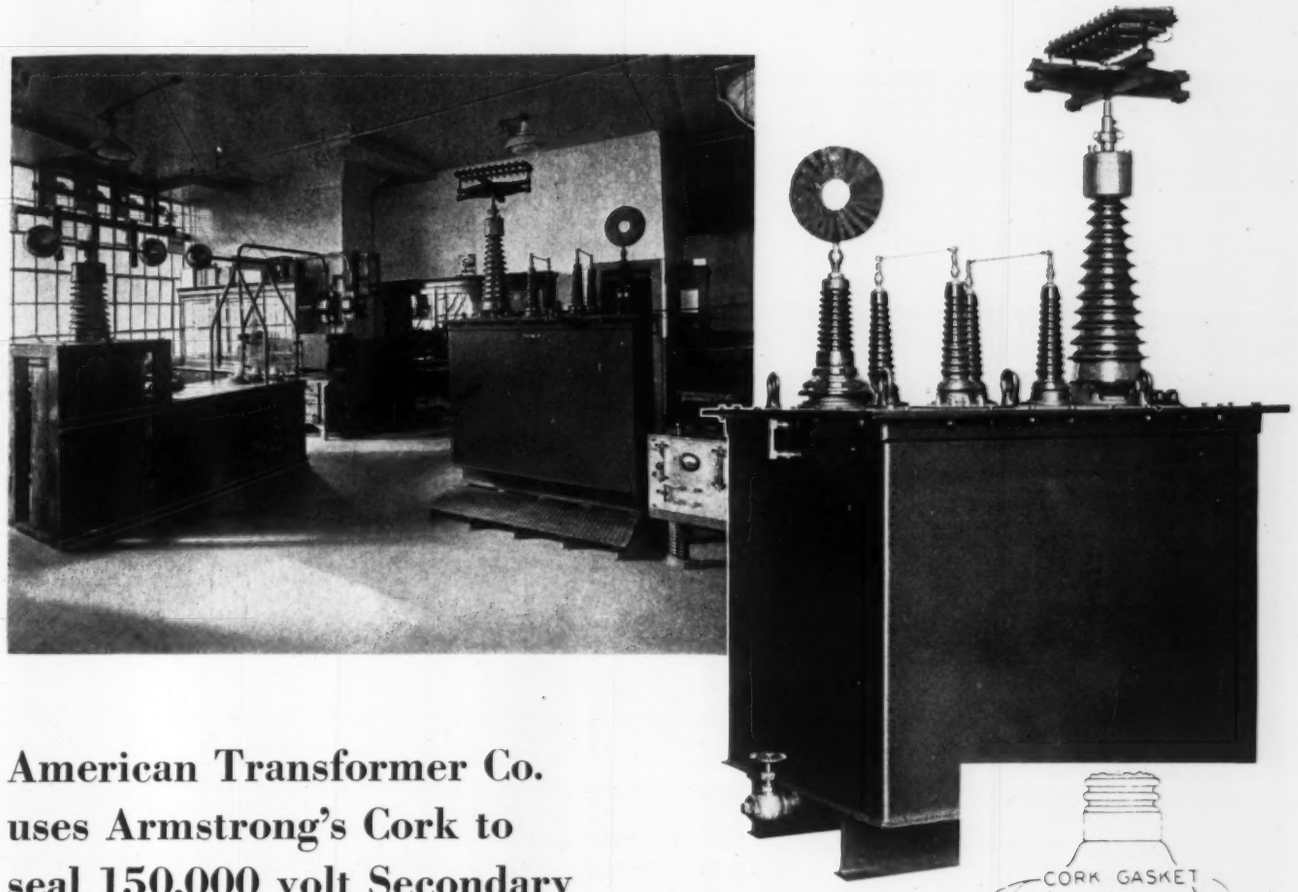
DISK switches of a new compact design are a recent development of Square D Co., Detroit. The new switch, shown herewith, has front



Copper switch contacts on new disk switches are reinforced by rustless steel springs

operation and requires little mounting space. It has a quick make and quick break action and may be obtained either fused or unfused. Copper switch contacts are reinforced by rustless steel springs. The switch is rated for either 30 or 60 ampere, single pole, two pole, two wire solid neutral or three wire solid neutral.

CORK LASTS LONGER



American Transformer Co. uses Armstrong's Cork to seal 150,000 volt Secondary Testing Transformer

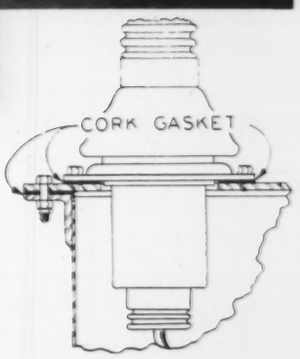
SEEKING a seal that would last for years, not just for months, the American Transformer Company tested various gasket materials—then chose Armstrong's Cork Gaskets to seal and cushion joints of their high voltage transformers. Three words tell why...

Cork lasts longer . . . Its efficiency is unimpaired by time.

Unlike other materials, gaskets of Armstrong's Cork *won't* set, *won't* harden, won't deteriorate progressively and leak oil after a few months, or even a few years.

Strange? Not at all, when you realize cork is *not* fibrous. Cork doesn't act like a sponge when exposed to oil. Cork is a mass of millions of tiny air-filled cells. That's why cork is buoyant. That's why oil can't penetrate its surface. That's why *time* has no effect on Armstrong's Cork Gaskets. They don't shrink, stretch, or harden. They keep on *cushioning*.

With its microscopic air-cell structure, cork is buoyant, resilient, compressible, and sound-absorbent. It resists the passage of heat, moisture, and liquids. It presents a gripping frictional surface and stands up in service without progressive deterioration.



SEALED FOR SURE! *High voltage transformers in the testing laboratory of Electric Service Supplies Company, Philadelphia, Pa. No moisture can enter. One large gasket seals between the heavy metal cover and the cast iron jacket. Small gaskets cushion the base of each porcelain bushing.*

Engineers, Designers, Manufacturers

Perhaps Armstrong's Cork can help you make *your* product last longer, work more efficiently, or cost less to operate. Feel free to consult our Industrial Sales Engineers on any problems of sealing, cushioning, sound deadening, friction, or insulation. Outline your needs, and if possible, send a blueprint. Address Armstrong Cork & Insulation Company, Industrial Sales Division, 918 Arch Street, Lancaster, Pennsylvania.

Armstrong's (A) Product

Armstrong's CORK

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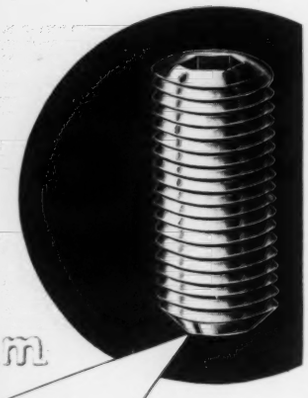

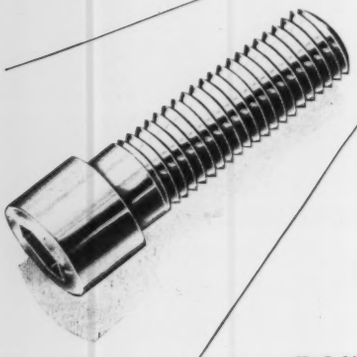

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Improved design of machines or appliances, to include betterment of component parts, should include the screws to hold them together. ALLEN has bettered hollow screws by making them of Chrome-Molybdenum steel, specially heat-treated. We will gladly supply samples for your experimental work in sizes you specify for the job in hand. They may suggest advantages in your assembly-detail.

THE ALLEN MFG. COMPANY

HARTFORD, CONN. U. S. A.

Predicting Gear Efficiency Easily and Accurately

(*Concluded from Page* 32)

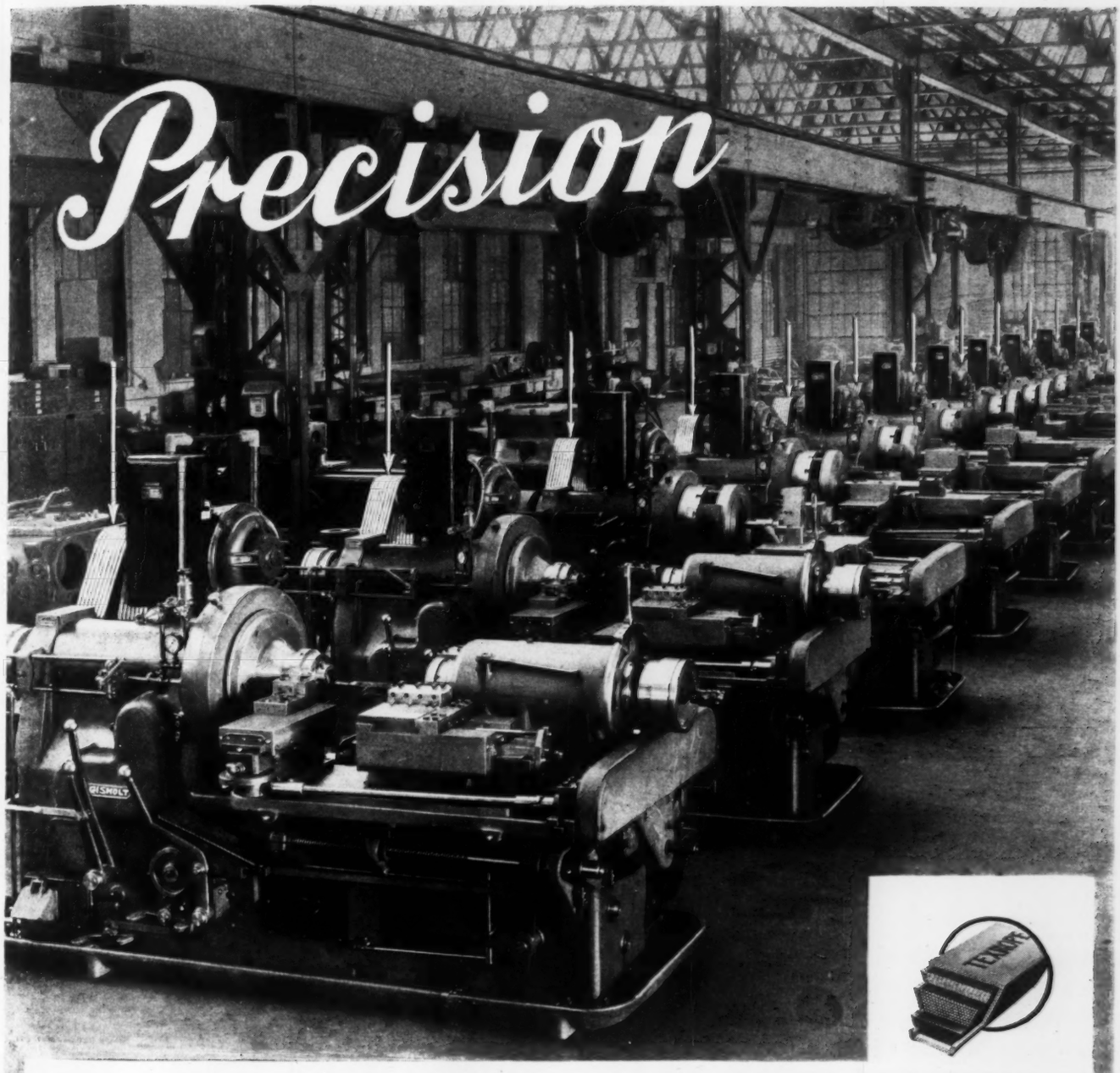
the curves such that there was a considerable difference in the coefficient values between curve "A" and curve "E." The general effect of other influences, however, is to translate a series of curves in a vertical direction on the graph while their relative positions remain unaltered.

From a practical point of view the condition of contact between the teeth of the gears is almost as important as the type of lubricant used. One object of the worm gear designer is to obtain a large zone of contacting surface and to provide adequate lubrication. Lubrication is effected by the action of the teeth carrying in a wedge of oil which prevents metal to metal contact. Now when a worm tooth under load shows that contact is occurring heavily on either the "entering" or "leaving" side, the coefficient of friction is increased considerably over its normal value with a consequent drop in efficiency. It is probable that insufficient lubrication produces a condition approaching metal to metal contact. For the best results the marking should be as shown in Fig. 3 when the gears are working under normal load.

No-Load Losses Must Be Noted

It will be seen that the efficiency obtained from these charts is not strictly the overall efficiency since there are no-load constant losses to be added to the frictional loss. These are due to bearing losses and to oil churning, and experiment has shown them to vary with the center distance of the gears and the rubbing speed. However, as long as the oil in the gear case is kept at the correct level and the rubbing velocity less than about 2000 feet per minute, the no-load losses do not cause appreciable reduction in the overall efficiency from that given by the use of the charts.

THE plasticity committee of the Applied Mechanics division, American Society of Mechanical Engineers, is now co-ordinating its work with the activities of the Society of Rheology and is preparing a report reviewing the theories of strength. It is also conducting a survey on actual problems in plasticity that are being encountered in industry. Dr. Ing. Nadai, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., is chairman of the committee.



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are designed to meet the most exact requirements of machine tools. Scientifically produced Texrope belts operating over accurately machined sheaves is assurance of vibrationless power transmission. The machine tool buyer of today rightfully demands accuracy to produce uniform products. To make this possible throughout the life of the machines it is of vital importance to equip them with genuine Texrope Drives. They require no lubrication or belt dressing whatsoever, in fact, very little attention .... For Texrope Bulletin 1228-K write the nearest district office or Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

Texrope Belts are made by B. F. Goodrich for Allis-Chalmers. Complete stocks are carried in Allis-Chalmers warehouses all over the globe. When your belts need replacement the nearest Allis-Chalmers Office will serve you promptly.

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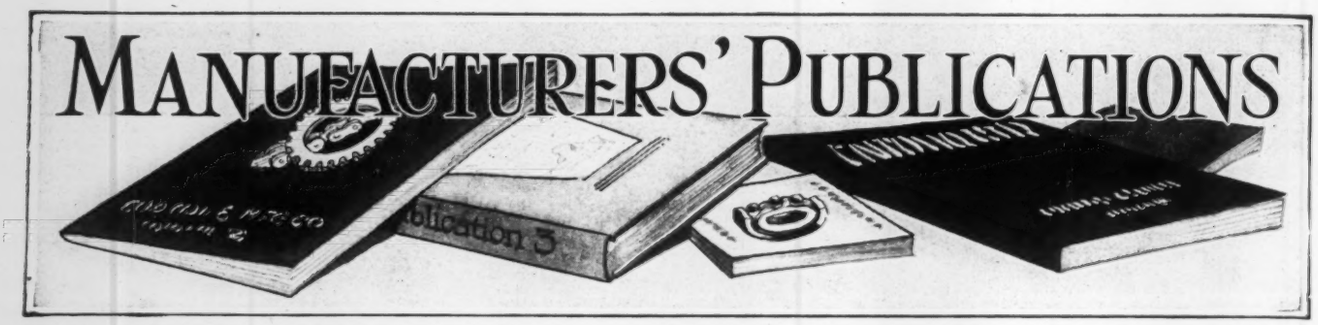
TEXROPE DRIVES

THE DRIVES THAT REVOLUTIONIZED TRANSMISSION PRACTICE • • •

MANUFACTURERS' PUBLICATIONS



Publications listed in this section may be obtained by engineers responsible for design from the manufacturers of the products through MACHINE DESIGN

CAST PARTS—Loose leaf sheets designed to give, in conjunction with the sheets noted in the August issue, complete information on centrifugally cast bronze alloys are being distributed by Shenango-Penn Mold Co., Dover, O. The latest sheets include a table of melting points and weights of metals and a table giving bearing pressures for various classes of bearings. Also, they cover the various characteristics and uses of the company's alloys No. 5, 9, 11, 13, 17, 18 and 19.

CONTROLS (ELECTRICAL)—General service switches and an improved line of Type C switches with quick make and quick break are described in a recent bulletin of Square D Co., Detroit. The various sizes in the line and their capacities are presented completely.

CONTROLS (ELECTRICAL)—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has published a leaflet on heavy duty timestarters. The controls are designed for the positive starting and protection of constant speed direct current motors in mill and mine service.

DRIVES—Motoreducers which combine standard makes of motors with Falk speed reducers are announced in bulletin No. 260 of Falk Corp., Milwaukee. The bulletin covers the three types of units made, integral, flexible and all-motor, includes cross-sectional drawings of the units and gives dimensions, features of design, and selection and rating tables.

ELECTRICAL EQUIPMENT—General Electric Co., Schenectady, N. Y., has prepared an attractive bulletin, GEA-1586, on electric equipment for woodworking machinery. The equipment treated in detail includes induction frequency converters and converter sets, other converters, transformers, motors, alternators and other necessary controls.

ENGINEERING DEPARTMENT SUPPLIES—National Consumers Paper Corp., New York, is distributing a sample book which contains a special selection of the most popular types of tracing, drawing and detail papers.

FINISHES—Acidseal paints, rubber derivatives that minimize the corrosive action of acids and alkalies on materials, are announced and described in a bulletin of B. F. Goodrich Rubber Co., Akron, O. The material is available in both primer and finish coat types.

LUBRICATION AND LUBRICATING EQUIPMENT—The September issue of the magazine on lubrication published by Texas Co., New York, is devoted to problems of lubrication in the gas engine.

MOTORS—Howell Electric Motors Co., Howell, Mich., has issued a folder describing its new motors which have a capacitor built into the case. These motors, similar in external appearance to the usual types, are manufactured in both horizontal and vertical models, with horsepowers from ⅛ to 1/3.

MOTORS—Applications and distinctive features of line-start type CS squirrel cage induction motors are included in a leaflet issued by Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa. These motors are equipped with sleeve bearings, are available for all commercial frequencies and voltages, and are built in sizes from 3 to 300 horsepower. They are designed for all constant speed, general purpose applications.

MOTOR PARTS—Boxill-Bruel Carbon Co., Columbia Park, O., has issued catalog No. 13 dealing specifically with carbon brushes for single phase and other fractional horsepower motors.

PUMPS—Tomkins-Johnson Co., Jackson, Mich., is distributing a catalog insert describing its new pumps. These pumps, for water or oil, require no check valve and must be primed only when first installed.

PUMPS—High pressure hydraulic pumps both horizontal and vertical are covered in bulletin No. 36 of Baldwin Southwark Corp., Philadelphia. The bulletin includes a description of the pumps, and tables of dimensions and capacities.

SHEETS AND PLATES—American Sheet & Tin Plate Co., Pittsburgh, has issued an attractive booklet on stainless steel sheets and light plates. The booklet gives the chemical analysis, physical properties, processing permissible and applications of the products, and is illustrated with application photographs.

STEEL (ALLOY)—Nickel clad sheets for all uses are presented pictorially and applications described in a recent bulletin issued by Lukens Steel Co., Coatesville, Pa. applications. A recent catalog insert of the company describes alternating current hoist motors. These type KR, totally enclosed units have high starting torque.

STEEL PRODUCTS—Youngstown Sheet & Tube Co., Youngstown, O., has prepared a complete bulletin entitled "What We Make," which presents all of the steel products manufactured by the company.

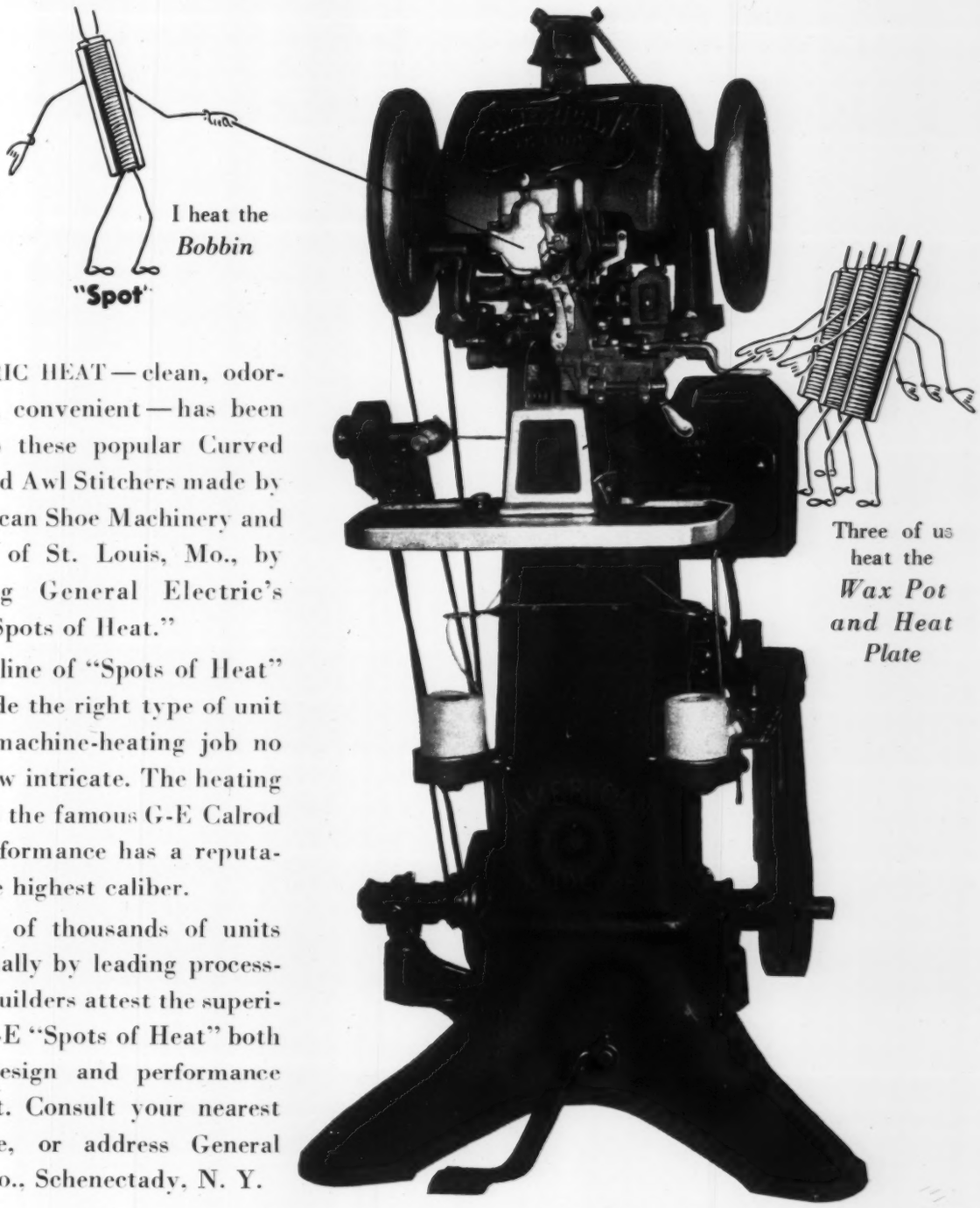
TUBES—Welded tubing of stainless steel manufactured by Carpenter Steel Co., New York, is covered in a bulletin of the company. General information, physical properties, working instructions and analysis are given.

WELDED PARTS AND EQUIPMENT—Numerous ap-

The "American Beauty"

Shoe-Stitching Machine

Equipped with G-E "Spots of Heat"



ELECTRIC HEAT — clean, odorless, safe, convenient — has been built into these popular Curved Needle and Awl Stitchers made by the American Shoe Machinery and Tool Co. of St. Louis, Mo., by employing General Electric's famous "Spots of Heat."

The G-E line of "Spots of Heat" can provide the right type of unit for any machine-heating job no matter how intricate. The heating element is the famous G-E Calrod whose performance has a reputation of the highest caliber.

Hundreds of thousands of units used annually by leading process-machine builders attest the superiority of G-E "Spots of Heat" both from a design and performance standpoint. Consult your nearest G-E office, or address General Electric Co., Schenectady, N. Y.

570-188

GENERAL ELECTRIC

plications of inorganic flux coated welding electrodes are described in a new booklet just published by Metal & Thermit Corp., New York. The booklet describes the welding of mild steel and boiler plate, stainless steel alloys, manganese steel, high carbon steel and stainless iron.

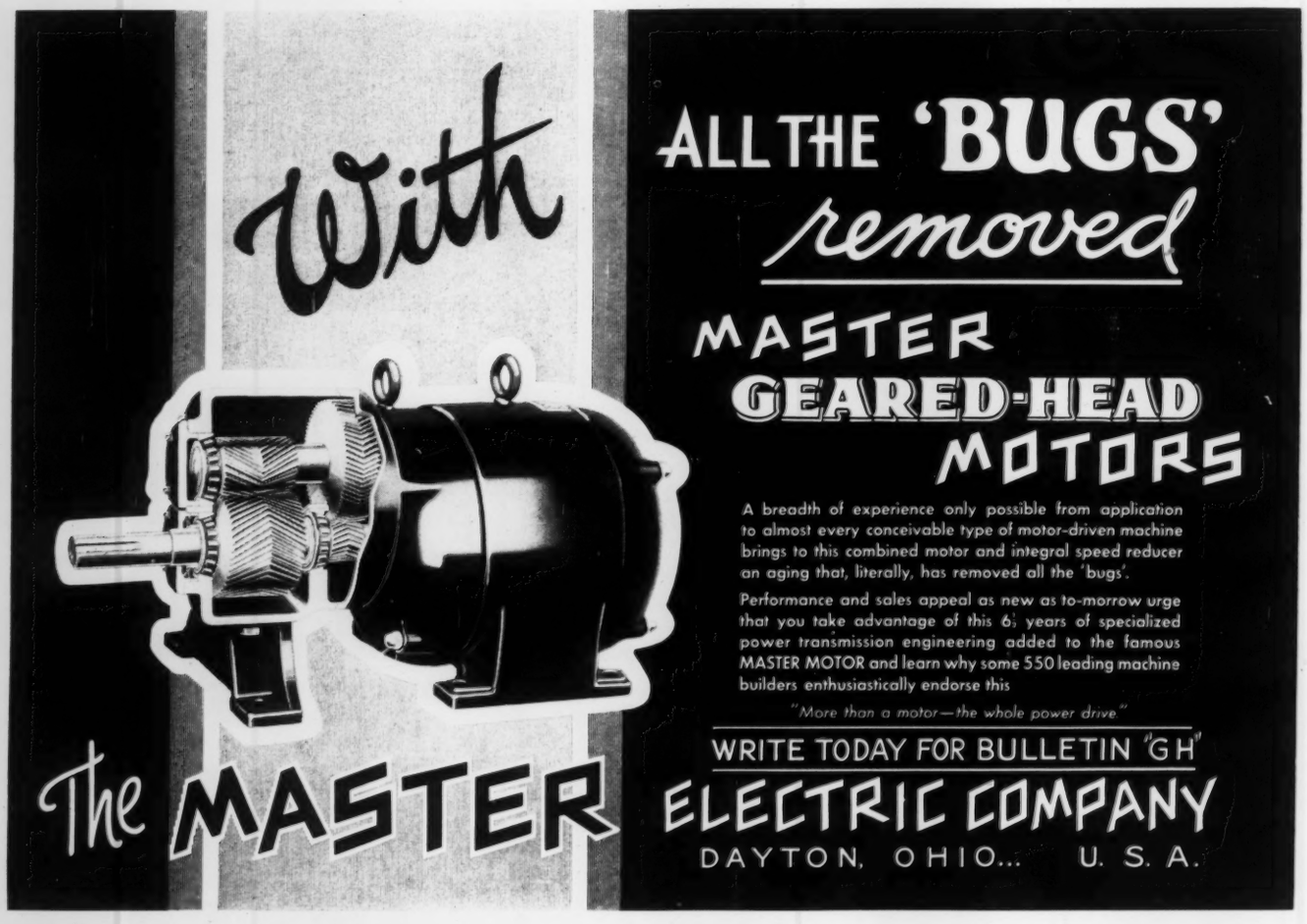
WIRE CLOTH—Concise information of value for both inexperienced and experienced users of wire cloth is included in catalog No. 32 of Newark Wire Cloth Co., Newark, N. J. The catalog, which is more nearly a handbook, includes 400-mesh cloth, cloth of a number of alloys, and full information on metallic filter cloth and gasketed metallic filter cloth. A glossary of wire cloth terms is presented.

Research Publications

Equilibrium Studies in Systems Containing Magnesium Oxide, Iron Oxide and Magnesium Aluminate, by Henry G. Fisk and William J. McCaughey. Iron oxide passes into solid solution in periclase to a considerable degree at high temperatures. The degree and character of this solution depends upon the temperature and upon the amount of iron oxide present. This bulletin deals comprehensively with the subject, presents the results in the form of tables and charts, and includes photomicrographs of the specimens. Published as bulletin No. 70 by Ohio State university, Columbus, O. 44 pages. Forty cents.

Aids to American Business. A complete resume of the activities of the department of commerce and descriptions of how trade associations and their members can use the services available and how they have been using them is contained in this booklet prepared by American Trade Association Executives. Available through department of commerce, Washington. 38 pp. Free.

Effect of Antimony on the Mechanical Properties of a Bearing Bronze, by C. E. Eggenschwiler. A study was made of the effect of small additions of antimony upon the hardness, the microstructure, the Izod impact value, deformation under pounding, and the broaching properties of a bearing bronze containing 80 per cent copper, 10 per cent tin and 10 per cent lead. Smaller additions of antimony had no effect upon the lead distribution, the microstructure and the machinability under broaching, but decreased the Izod impact value. Within the range of antimony additions studied, the minimum deformation under pounding occurred at 0.2 per cent antimony. Brinell hardness of about 60 in the antimony-free alloy was increased to about 68 with the addition of 0.2 per cent antimony but showed no further significant change with larger additions of antimony. Published as RP442 by bureau of standards. Available from Superintendent of Documents, Government Printing office, Washington. 10 pp. 5 cents.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